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CAPITAL AND OPERATING COSTS
FOR INDUSTRIAL BOILERS

Prepared by

PEDCo Environmental, Inc.
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Cincinnati, Ohio 45246

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EPA Project Officer

John M. Pratapas
Economic Analysis Branch
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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1.0 INTRODUCTION

The purpose of this study is to develop general equations to relate the costs of various types of boilers to parameters such as fuel type, fuel analysis, operating hours, and input capacity. The equations are to represent a cross section of fuel types including several ranks of coal, distillate oil, residual oil, and natural gas, and a cross section of boiler types including fire-tube, package water-tube, field-erected water-tube, stoker coal-fired, and pulverized coal-fired.

These equations will be used by the Office of Air Quality, Planning and Standards (OAQPS) as input to a computer model to be used in evaluating the economic impacts of various alternative regulatory scenarios as applied to new industrial boilers.

The specific equations to be developed were for distillate oil-fired fire-tube, residual oil-fired fire-tube, natural gas-fired fire-tube, stoker coal-fired package water-tube, residual oil/natural gas-fired package water-tube, distillate oil/natural gas-fired package water-tube, stoker coal-fired field-erected water-tube, pulverized coal-fired field-erected water-tube, residual oil/natural gas-fired field-erected water-tube, and distillate oil/natural gas-fired field-erected water-tube. To develop these equations, 51 specific boiler/fuel combinations

were costed. In addition, costs for 8 other boiler/fuel combinations developed previously under Contract No. 68-02-2603, Task 19 were used in development of the equations. This report summarizes the equations for the 10 major boiler/fuel combinations and presents detailed costs for the 59 specific boilers used in developing these equations.

In Section 2 are presented the characteristics of the specific boiler types, fuels, and sizes for which costs were prepared. Section 3 presents the detailed costs for 59 boilers and the methodology used to obtain costs. Section 4 presents the equations describing boiler costs and the methodology for obtaining these equations. Appendices A, B, and C present the detailed cost tables for the 59 boilers.

2.0 SPECIFIC BOILERS AND CHARACTERISTICS

The boilers were selected jointly by PEDCo and OAQPS for detailed costing to cover the size range and fuel types of boilers typically found in industrial use. A minimum number of boilers were chosen that would still provide a good basis for development of boiler cost equations. The boilers selected for detailed costing are listed in Table 1.

Operational and design parameters had to be specified for the selected boilers before the costs could be estimated. The following key operating and design parameters are required for each boiler:

- ° Boiler configuration
- ° Design heat input rate
- ° Fuel analysis
- ° Fuel consumption
- ° Excess air usage
- ° Flue gas characteristics
- ° Load factor

The values determined for these operating and design parameters (Tables 2 through 19) are based on published data and practical knowledge of good boiler operating practices. The methodology used to determine these values is described below.

TABLE 1. LIST OF BOILERS COSTED FOR DEVELOPMENT OF COST EQUATIONS

| Boiler type | Heat input, 10 ⁶ Btu/h | Steam generating Capacity, 10 ³ lb/h | Fuel |
|--|--------------------------------------|--|----------------------------|
| Package water-tube, underfeed stoker | 15 | 12.0 | Eastern high-sulfur coal |
| Package water-tube, underfeed stoker | 15 | 12.0 | Eastern low-sulfur coal |
| Package water-tube, underfeed stoker | 15 | 12.0 | Subbituminous coal |
| Package water-tube, underfeed stoker | 15 | 12.0 | Eastern medium-sulfur coal |
| Package water-tube, underfeed stoker | 30 | 24.0 | Eastern high-sulfur coal |
| Package water-tube, underfeed stoker | 30 | 24.0 | Eastern low-sulfur coal |
| Package water-tube, underfeed stoker | 30 | 24.0 | Subbituminous coal |
| Package water-tube, underfeed stoker | 30 | 24.0 | Eastern medium-sulfur coal |
| Package water-tube, underfeed stoker | 60 | 48.0 | Eastern high-sulfur coal |
| Package water-tube, underfeed stoker | 60 | 48.0 | Eastern low-sulfur coal |
| Package water-tube, underfeed stoker | 60 | 48.0 | Subbituminous coal |
| Package water-tube, underfeed stoker | 60 | 48.0 | Eastern medium-sulfur coal |
| Field-erected water-tube spreader stoker | 75 | 60.0 | Eastern high-sulfur coal |
| Field-erected water-tube spreader stoker | 75 | 60.0 | Eastern low-sulfur coal |
| Field-erected water-tube spreader stoker | 75 | 60.0 | Subbituminous coal |
| Field-erected water-tube spreader stoker | 75 | 60.0 | Eastern medium-sulfur coal |
| Field-erected water-tube spreader stoker | 150 | 120.0 | Eastern high-sulfur coal |
| Field-erected water-tube spreader stoker | 150 | 120.0 | Eastern low-sulfur coal |
| Field-erected water-tube spreader stoker | 150 | 120.0 | Subbituminous coal |
| Field-erected water-tube spreader stoker | 150 | 120.0 | Eastern medium-sulfur coal |
| Field-erected water-tube spreader stoker | 200 | 160.0 | Eastern high-sulfur coal |
| Field-erected water-tube spreader stoker | 200 | 160.0 | Eastern low-sulfur coal |
| Field-erected water-tube spreader stoker | 200 | 160.0 | Subbituminous coal |
| Field-erected water-tube spreader stoker | 200 | 160.0 | Eastern medium-sulfur coal |
| Field-erected water-tube pulverized | 200 | 160.0 | Eastern high-sulfur coal |
| Field-erected water-tube pulverized | 200 | 160.0 | Eastern low-sulfur coal |
| Field-erected water-tube pulverized | 200 | 160.0 | Subbituminous coal |
| Field-erected water-tube pulverized | 200 | 160.0 | Eastern medium-sulfur coal |
| Field-erected water-tube pulverized | 400 | 320.0 | Eastern high-sulfur coal |
| Field-erected water-tube pulverized | 400 | 320.0 | Eastern low-sulfur coal |
| Field-erected water-tube pulverized | 400 | 320.0 | Subbituminous coal |
| Field-erected water-tube pulverized | 400 | 320.0 | Eastern medium-sulfur coal |

(continued)

TABLE 1. (continued)

| Boiler type | Heat input, 10 ⁶ Btu/h | Steam generating Capacity, 10 ³ lb/h | Fuel |
|-------------------------------------|--------------------------------------|--|----------------------------|
| Field-erected water-tube pulverized | 700 | 560.0 | Eastern high-sulfur coal |
| Field-erected water-tube pulverized | 700 | 560.0 | Eastern low-sulfur coal |
| Field-erected water-tube pulverized | 700 | 560.0 | Subbituminous coal |
| Field-erected water-tube pulverized | 700 | 560.0 | Eastern medium-sulfur coal |
| Package fire-tube | 5 | 4.0 | Distillate oil |
| Package fire-tube | 5 | 4.0 | Natural gas |
| Package fire-tube | 5 | 4.0 | Residual oil |
| Package fire-tube | 15 | 12.0 | Distillate oil |
| Package fire-tube | 15 | 12.0 | Natural gas |
| Package fire-tube | 15 | 12.0 | Residual oil |
| Package fire-tube | 29 | 23.2 | Distillate oil |
| Package fire-tube | 29 | 23.2 | Natural gas |
| Package fire-tube | 29 | 23.2 | Residual oil |
| Package water-tube | 30 | 24.0 | Residual oil/natural gas |
| Package water-tube | 60 | 48.0 | Residual oil/natural gas |
| Package water-tube | 100 | 80.0 | Residual oil/natural gas |
| Package water-tube | 150 | 120.0 | Residual oil/natural gas |
| Field-erected water-tube | 200 | 160.0 | Residual oil/natural gas |
| Field-erected water-tube | 400 | 320.0 | Residual oil/natural gas |
| Field-erected water-tube | 700 | 560.0 | Residual oil/natural gas |
| Package water-tube | 30 | 24.0 | Distillate oil/natural gas |
| Package water-tube | 60 | 48.0 | Distillate oil/natural gas |
| Package water-tube | 100 | 80.0 | Distillate oil/natural gas |
| Package water-tube | 150 | 120.0 | Distillate oil/natural gas |
| Field-erected water-tube | 200 | 160.0 | Distillate oil/natural gas |
| Field-erected water-tube | 400 | 320.0 | Distillate oil/natural gas |
| Field-erected water-tube | 700 | 560.0 | Distillate oil/natural gas |

**TABLE 2. DESIGN PARAMETERS FOR COAL-FIRED, PACKAGE,
WATER-TUBE, UNDERFEED-STOKER BOILERS**

| | | | | |
|--|---------------------------------|--------------------------------|---------------------------|-----------------------------------|
| Thermal input, MW (10^6 Btu/h) | 4.4 (15) | 4.4 (15) | 4.4 (15) | 4.4 (15) |
| Fuel | Eastern high-sulfur coal | Eastern low-sulfur coal | Subbituminous coal | Eastern medium-sulfur coal |
| Fuel rate, kg/s (tons/h) | 0.16 (0.64) | 0.14 (0.54) | 0.20 (0.78) | 0.14 (0.57) |
| Analysis | | | | |
| % sulfur | 3.5 | 0.9 | 0.6 | 2.3 |
| % ash | 10.6 | 6.9 | 5.4 | 13.2 |
| Heating value, kJ/kg (Btu/lb) | 27,447 (11,800) | 32,099 (13,800) | 22,330 (9,600) | 30,703 (13,200) |
| Excess air, % | 50 | 50 | 50 | 50 |
| Flue gas flow rate, m³/s (acfm) | 3.04 (6450) | 2.88 (6100) | 2.95 (6250) | 2.98 (6325) |
| Flue gas temperature, °K (°F) | 478 (400) | 450 (350) | 450 (350) | 450 (350) |
| Load factor, % | 60 | 60 | 60 | 60 |
| Utility requirements | | | | |
| Electricity, kW | 190 | 162 | 233 | 169 |
| Process water, liters/s (gpm) | 0.30 (4.8) | 0.30 (4.8) | 0.30 (4.8) | 0.30 (4.8) |
| Manpower requirements | | | | |
| Direct labor, man-yr | 5 | 5 | 5 | 5 |
| Supervision, man-yr | 2 | 2 | 2 | 2 |
| Maintenance labor, man-yr | 2 | 2 | 2 | 2 |
| Bottom ash disposal requirement, kg/h (ton/h) | 46.16 (0.05) | 25.35 (0.03) | 28.66 (0.03) | 51.19 (0.06) |

**TABLE 3. DESIGN PARAMETERS FOR COAL-FIRED, PACKAGE,
WATER-TUBE, UNDERFEED-STOKER BOILERS**

| | | | | |
|--|---------------------------------|--------------------------------|---------------------------|-----------------------------------|
| Thermal input, MW (10^6 Btu/h) | 8.8 (30) | 8.8 (30) | 8.8 (30) | 8.8 (30) |
| Fuel | Eastern high-sulfur coal | Eastern low-sulfur coal | Subbituminous coal | Eastern medium-sulfur coal |
| Fuel rate, kg/s (ton/h) | 0.32 (1.27) | 0.27 (1.09) | 0.39 (1.56) | 0.28 (1.13) |
| Analysis | | | | |
| % sulfur | 3.5 | 0.9 | 0.6 | 2.3 |
| % ash | 10.6 | 6.9 | 5.4 | 13.2 |
| Heating value, kJ/kg (Btu/lb) | 27,447 (11,800) | 32,099 (13,800) | 22,330 (9600) | 30,703 (13,200) |
| Excess air, % | 50 | 50 | 50 | 50 |
| Flue gas flow rate, m³/s (acfm) | 6.09 (12,900) | 5.76 (12,200) | 5.90 (12,500) | 5.97 (12,650) |
| Flue gas temperature, °K (°F) | 478 (400) | 450 (350) | 450 (350) | 450 (350) |
| Load factor, % | 60 | 60 | 60 | 60 |
| Utility requirements | | | | |
| Electricity, kW | 296 | 253 | 364 | 264 |
| Process water, liters/s (gpm) | 0.61 (9.6) | 0.61 (9.6) | 0.61 (9.6) | 0.61 (9.6) |
| Manpower requirements | | | | |
| Direct labor, man-yr | 6 | 6 | 6 | 6 |
| Supervision, man-yr | 2 | 2 | 2 | 2 |
| Maintenance labor, man-yr | 2 | 2 | 2 | 2 |
| Bottom ash disposal requirement, kg/h (ton/h) | 90.71 (0.10) | 54.43 (0.06) | 54.43 (0.06) | 99.78 (0.11) |

**TABLE 4. DESIGN PARAMETERS FOR COAL-FIRED, PACKAGE,
WATER-TUBE, UNDERFEED-STOKER BOILERS**

| | | | | |
|--|---------------------------------|--------------------------------|---------------------------|-----------------------------------|
| Thermal input, MW (10^6 Btu/h) | 17.6 (60) | 17.6 (60) | 17.6 (60) | 17.6 (60) |
| Fuel | Eastern high-sulfur coal | Eastern low-sulfur coal | Subbituminous coal | Eastern medium-sulfur coal |
| Fuel rate, kg/s (tons/h) | 0.64 (2.54) | 0.55 (2.18) | 0.78 (3.12) | 0.57 (2.25) |
| Analysis | | | | |
| % sulfur | 3.5 | 0.9 | 0.6 | 2.3 |
| % ash | 10.6 | 6.9 | 5.4 | 13.2 |
| Heating value, kJ/kg (Btu/lb) | 27,447 (11,800) | 32,099 (13,800) | 22,330 (9,600) | 30,703 (13,200) |
| Excess air, % | 50 | 50 | 50 | 50 |
| Flue gas flow rate, m³/s (acfm) | 12.18 (25,800) | 11.52 (24,400) | 11.80 (25,000) | 11.94 (25,300) |
| Flue gas temperature, °K (°F) | 478 (400) | 450 (350) | 450 (350) | 450 (350) |
| Load factor, % | 60 | 60 | 60 | 60 |
| Utility requirements | | | | |
| Electricity, kW | 392 | 335 | 482 | 350 |
| Process water, liters/s (gpm) | 1.21 (19.2) | 1.21 (19.2) | 1.21 (19.2) | 1.21 (19.2) |
| Manpower requirements | | | | |
| Direct labor, man-yr | 7 | 7 | 7 | 7 |
| Supervision, man-yr | 4 | 4 | 4 | 4 |
| Maintenance labor, man-yr | 4 | 4 | 4 | 4 |
| Bottom ash disposal requirement, kg/h (ton/h) | 181.42 (0.20) | 99.78 (0.11) | 117.92 (0.13) | 199.56 (0.22) |

**TABLE 5. DESIGN PARAMETERS FOR COAL-FIRED, FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILERS**

| | | | | |
|--|---------------------------------|--------------------------------|---------------------------|-----------------------------------|
| Thermal input, MW (10^6 Btu/h) | 22.0 (75) | 22.0 (75) | 22.0 (75) | 22.0 (75) |
| Fuel | Eastern high-sulfur coal | Eastern low-sulfur coal | Subbituminous coal | Eastern medium-sulfur coal |
| Fuel rate, kg/s (ton/h) | 0.80 (3.18) | 0.69 (2.72) | 0.99 (3.91) | 0.72 (2.82) |
| Analysis | | | | |
| % sulfur | 3.5 | 0.9 | 0.6 | 2.3 |
| % ash | 10.6 | 6.9 | 5.4 | 13.2 |
| Heating value, kJ/kg (Btu/lb) | 27,447 (11,800) | 32,099 (13,800) | 22,330 (9600) | 30,703 (13,200) |
| Excess air, % | 50 | 50 | 50 | 50 |
| Flue gas flow rate, m³/s (acfm) | 15.24 (32,300) | 14.21 (30,100) | 14.82 (31,400) | 14.73 (31,200) |
| Flue gas temperature, °K (°F) | 478 (400) | 450 (350) | 450 (350) | 450 (350) |
| Load factor, % | 60 | 60 | 60 | 60 |
| Utility requirements | | | | |
| Electricity, kW | 425 | 363 | 523 | 379 |
| Process water, liters/s (gpm) | 1.52 (24.0) | 1.52 (24.0) | 1.52 (24.0) | 1.52 (24.0) |
| Manpower requirements | | | | |
| Direct labor, man-yr | 8 | 8 | 8 | 8 |
| Supervision, man-yr | 4 | 4 | 4 | 4 |
| Maintenance labor, man-yr | 4 | 4 | 4 | 4 |
| Bottom ash disposal requirement, kg/h (ton/h) | 107.03 (0.12) | 59.59 (0.07) | 67.04 (0.07) | 118.19 (0.13) |

**TABLE 6. DESIGN PARAMETERS FOR COAL-FIRED, FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILERS**

| | | | | |
|--|---------------------------------|--------------------------------|---------------------------|-----------------------------------|
| Thermal input, MW (10^6 Btu/h) | 44.0 (150) | 44.0 (150) | 44.0 (150) | 44.0 (150) |
| Fuel | Eastern high-sulfur coal | Eastern low-sulfur coal | Subbituminous coal | Eastern medium-sulfur coal |
| Fuel rate, kg/s (ton/h) | 1.60 (6.36) | 1.38 (5.44) | 1.98 (7.82) | 1.43 (5.63) |
| Analysis | | | | |
| % sulfur | 3.5 | 0.9 | 0.6 | 2.3 |
| % ash | 10.6 | 6.9 | 5.4 | 13.2 |
| Heating value, kJ/kg (Btu/lb) | 27,447 (11,800) | 32,099 (13,800) | 22,330 (9600) | 30,703 (13,200) |
| Excess air, % | 50 | 50 | 50 | 50 |
| Flue gas flow rate, m³/s (acfm) | 30.58 (64,800) | 28.69 (60,800) | 29.64 (62,800) | 29.72 (63,000) |
| Flue gas temperature, °K (°F) | 478 (400) | 450 (350) | 450 (350) | 450 (350) |
| Load factor, % | 60 | 60 | 60 | 60 |
| Utility requirements | | | | |
| Electricity, kW | 628 | 537 | 773 | 561 |
| Process water, liters/s (gpm) | 3.03 (48.0) | 3.03 (48.0) | 3.03 (48.0) | 3.03 (48.0) |
| Manpower requirements | | | | |
| Direct labor, man-yr | 12 | 12 | 12 | 12 |
| Supervision, man-yr | 4 | 4 | 4 | 4 |
| Maintenance labor, man-yr | 4 | 4 | 4 | 4 |
| Bottom ash disposal requirement, kg/h (ton/h) | 217.70 (0.24) | 117.92 (0.13) | 136.07 (0.15) | 235.85 (0.26) |

**TABLE 7. DESIGN PARAMETERS FOR COAL-FIRED, FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILERS**

| | | | | |
|--|---------------------------------|--------------------------------|---------------------------|-----------------------------------|
| Thermal input, MW (10^6 Btu/h) | 58.6 (200) | 58.6 (200) | 58.6 (200) | 58.6 (200) |
| Fuel | Eastern high-sulfur coal | Eastern low-sulfur coal | Subbituminous coal | Eastern medium-sulfur coal |
| Fuel rate, kg/s (tons/h) | 2.13 (8.48) | 1.84 (7.25) | 2.64 (10.43) | 1.91 (7.51) |
| Analysis | | | | |
| % sulfur | 3.5 | 0.9 | 0.6 | 2.3 |
| % ash | 10.6 | 6.9 | 5.4 | 13.2 |
| Heating value, kJ/kg (Btu/lb) | 27,447 (11,800) | 32,099 (13,800) | 22,330 (9,600) | 30,703 (13,200) |
| Excess air, % | 50 | 50 | 50 | 50 |
| Flue gas flow rate, m³/s (acfm) | 40.77 (86,400) | 38.27 (81,100) | 39.52 (83,700) | 39.65 (84,000) |
| Flue gas temperature, °K (°F) | 478 (400) | 450 (350) | 450 (350) | 450 (350) |
| Load factor, % | 60 | 60 | 60 | 60 |
| Utility requirements | | | | |
| Electricity, kW | 813 | 695 | 1001 | 726 |
| Process water, liters/s (gpm) | 4.04 (64.0) | 4.04 (64.0) | 4.04 (64.0) | 4.04 (64.0) |
| Manpower requirements | | | | |
| Direct labor, man-yr | 16 | 16 | 16 | 16 |
| Supervision, man-yr | 4 | 4 | 4 | 4 |
| Maintenance labor, man-yr | 6 | 6 | 6 | 6 |
| Bottom ash disposal requirement, kg/h (ton/h) | 281.20 (0.31) | 163.28 (0.18) | 181.42 (0.20) | 317.49 (0.35) |

**TABLE 8. DESIGN PARAMETERS FOR FIELD-ERECTED, WATER-TUBE,
PULVERIZED-COAL-FIRED BOILERS**

| | | | | |
|--|---------------------------------|--------------------------------|---------------------------|-----------------------------------|
| Thermal input, MW (10^6 Btu/h) | 58.6 (200) | 58.6 (200) | 58.6 (200) | 58.6 (200) |
| Fuel | Eastern high-sulfur coal | Eastern low-sulfur coal | Subbituminous coal | Eastern medium-sulfur coal |
| Fuel rate, kg/s (ton/h) | 2.13 (8.48) | 1.84 (7.25) | 2.64 (10.43) | 1.91 (7.51) |
| Analysis | | | | |
| % sulfur | 3.5 | 0.9 | 0.6 | 2.3 |
| % ash | 10.6 | 6.9 | 5.4 | 13.2 |
| Heating value, kJ/kg (Btu/lb) | 27,447 (11,800) | 32,099 (13,800) | 22,330 (9600) | 30,703 (13,200) |
| Excess air, % | 30 | 30 | 30 | 30 |
| Flue gas flow rate, m³/s (acfm) | 35.30 (74,800) | 33.32 (70,600) | 34.55 (73,200) | 34.62 (73,400) |
| Flue gas temperature, °K (°F) | 478 (400) | 450 (350) | 450 (350) | 450 (350) |
| Load factor, % | 60 | 60 | 60 | 60 |
| Utility requirements | | | | |
| Electricity, kW | 2052 | 1754 | 2526 | 1831 |
| Process water, liters/s (gpm) | 4.04 (64.0) | 4.04 (64.0) | 4.04 (64.0) | 4.04 (64.0) |
| Manpower requirements | | | | |
| Direct labor, man-yr | 16 | 16 | 16 | 16 |
| Supervision, man-yr | 4 | 4 | 4 | 4 |
| Maintenance labor, man-yr | 6 | 6 | 6 | 6 |
| Bottom ash disposal requirement, kg/h (ton/h) | 163.28 (0.18) | 90.71 (0.10) | 99.78 (0.11) | 181.42 (0.20) |

TABLE 9. DESIGN PARAMETERS FOR FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILERS

| | | | | |
|---|--------------------------|-------------------------|--------------------|----------------------------|
| Thermal input, MW (10^6 Btu/h) | 117.2 (400) | 117.2 (400) | 117.2 (400) | 117.2 (400) |
| Fuel | Eastern high-sulfur coal | Eastern low-sulfur coal | Subbituminous coal | Eastern medium-sulfur coal |
| Fuel rate, kg/s (ton/h) | 4.27 (16.95) | 3.65 (14.49) | 5.25 (20.83) | 3.82 (15.14) |
| Analysis | | | | |
| % sulfur | 3.5 | 0.9 | 0.6 | 2.3 |
| % ash | 10.6 | 6.9 | 5.4 | 13.2 |
| Heating value, kJ/kg (Btu/lb) | 27,447 (11,800) | 32,099 (13,800) | 22,330 (9600) | 30,703 (13,200) |
| Excess air, % | 30 | 30 | 30 | 30 |
| Flue gas flow rate, m^3/s (acfm) | 70.63 (149,600) | 66.80 (141,500) | 68.89 (146,000) | 71.35 (151,200) |
| Flue gas temperature, °K (°F) | 478 (400) | 450 (350) | 450 (350) | 478 (400) |
| Load factor, % | 60 | 60 | 60 | 60 |
| Utility requirements | | | | |
| Electricity, kW | 4142 | 3540 | 5097 | 3695 |
| Process water, liters/s (gpm) | 8.08 (128.0) | 8.08 (128.0) | 8.08 (128.0) | 8.08 (128.0) |
| Manpower requirements | | | | |
| Direct labor, man-yr | 28 | 28 | 28 | 28 |
| Supervision, man-yr | 6 | 6 | 6 | 6 |
| Maintenance labor, man-yr | 12 | 12 | 12 | 12 |
| Bottom ash disposal requirement, kg/h (ton/h) | 326.56 (0.36) | 181.42 (0.20) | 199.56 (0.22) | 362.84 (0.40) |

TABLE 10. DESIGN PARAMETERS FOR FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILERS

| | | | | |
|--|--------------------------|-------------------------|---------------------|----------------------------|
| Thermal input, MW (10^6 Btu/h) | 205.1 (700) | 205.1 (700) | 205.1 (700) | 205.1 (700) |
| Fuel | Eastern high-sulfur coal | Eastern low-sulfur coal | Subbituminous coal | Eastern medium-sulfur coal |
| Fuel rate, kg/s (tons/h) | 7.47 (29.66) | 6.39 (25.36) | 9.19 (36.46) | 6.68 (26.52) |
| Analysis | | | | |
| % sulfur | 3.5 | 0.9 | 0.6 | 2.3 |
| % ash | 10.6 | 6.9 | 5.4 | 13.2 |
| Heating value, kJ/kg (Btu/lb) | 27,447 (11,800) | 32,099 (13,800) | 22,330 (9,600) | 30,703 (13,200) |
| Excess air, % | 30 | 30 | 30 | 30 |
| Flue gas flow rate, m^3/s (acfm) | 123.55 (261,800) | 116.62 (247,100) | 120.93 (256,200) | 121.17 (256,900) |
| Flue gas temperature, °K (°F) | 478 (400) | 450 (350) | 450 (350) | 450 (350) |
| Load factor, % | 60 | 60 | 60 | 60 |
| Utility requirements | | | | |
| Electricity, kW | 7249 | 6195 | 8920 | 6466 |
| Process water, liters/s (gpm) | 14.14 (224.0) | 14.14 (224.0) | 14.14 (224.0) | 14.14 (224.0) |
| Manpower requirements | | | | |
| Direct labor, man-yr | 38 | 38 | 38 | 38 |
| Supervision, man-yr | 6 | 6 | 6 | 6 |
| Maintenance labor, man-yr | 16 | 16 | 16 | 16 |
| Bottom ash disposal requirement, kg/h (ton/h) | 570.43 (0.63) | 317.49 (0.35) | 357.22 (0.39) | 635.14 (0.70) |

TABLE 11. DESIGN PARAMETERS FOR PACKAGE, FIRE-TUBE
BOILERS FIRING RESIDUAL OIL

| | | | |
|--|---------------------|---------------------|---------------------|
| Thermal input, MW (10^6 Btu/h) | 1.5 (5) | 4.4 (15) | 8.5 (29) |
| Fuel | Residual oil | Residual oil | Residual oil |
| Fuel rate, m^3/h (gal/h) | 0.13 (33.4) | 0.38 (100.1) | 0.73 (193.6) |
| Analysis | | | |
| % sulfur | 3.0 | 3.0 | 3.0 |
| % ash | 0.1 | 0.1 | 0.1 |
| Heating value, MJ/ m^3 (Btu/gal) | 41,714 (149,800) | 41,714 (149,800) | 41,714 (149,800) |
| Excess air, % | 15 | 15 | 15 |
| Flue gas flow rate, m^3/s (acfm) | 0.75 (1,600) | 2.21 (4,700) | 4.28 (9,100) |
| Flue gas temperature, °K (°F) | 478 (400) | 478 (400) | 478 (400) |
| Load factor, % | 45 | 45 | 45 |
| Utility requirements | | | |
| Electricity, kW | 59 | 114 | 236 |
| Process water, liter/s (gpm) | 0.10 (1.6) | 0.30 (4.8) | 0.60 (9.5) |
| Manpower requirements | | | |
| Direct labor, man-yr | 4 | 4 | 4 |
| Supervision, man-yr | | 2 | 2 |
| Maintenance labor, man-yr | 0.5 | 1 | 1 |
| Bottom ash disposal requirement kg/h (tons/h) | Negligible | Negligible | Negligible |

TABLE 12. DESIGN PARAMETERS FOR PACKAGE, FIRE-TUBE
BOILERS FIRING DISTILLATE OIL

| | | | |
|---|------------------|------------------|------------------|
| Thermal input, MW (10^6 Btu/h) | 1.5 (5) | 4.4 (15) | 8.5 (29) |
| Fuel | Distillate oil | Distillate oil | Distillate oil |
| Fuel rate, m^3/h (gal/h) | 0.14 (36.0) | 0.41 (107.9) | 0.79 (208.6) |
| Analysis | | | |
| % sulfur | 0.5 | 0.5 | 0.5 |
| % ash | Trace | Trace | Trace |
| Heating value, MJ/ m^3 (Btu/gal) | 38,712 (139,000) | 38,712 (139,000) | 38,712 (139,000) |
| Excess air, % | 15 | 15 | 15 |
| Flue gas flow rate, m^3/s (acfm) | 0.81 (1700) | 2.36 (5000) | 4.45 (9700) |
| Flue gas temperature, °K (°F) | 450 (350) | 450 (350) | 450 (350) |
| Load factor, % | 45 | 45 | 45 |
| Utility requirements | | | |
| Electricity, kW | 59 | 114 | 236 |
| Process water, liter/s (gpm) | 0.10 (1.6) | 0.30 (4.8) | 0.60 (9.5) |
| Manpower requirements | | | |
| Direct labor, man-yr | 4 | 4 | 4 |
| Supervision, man-yr | 2 | 2 | 2 |
| Maintenance labor, man-yr | .5 | 1 | 1 |
| Bottom ash disposal requirement, kg/h (ton/h) | Negligible | Negligible | Negligible |

TABLE 13. DESIGN PARAMETERS FOR PACKAGE, FIRE-TUBE
BOILERS FIRING NATURAL GAS

| | | | |
|--|---------------|---------------|---------------|
| Thermal input, MW (10^6 Btu/h) | 1.5 (5) | 4.4 (15) | 8.5 (29) |
| Fuel | Natural gas | Natural gas | Natural gas |
| Fuel rate, m^3/s (ft^3/h) | 0.04 (5000) | 0.12 (15,000) | 0.23 (29,000) |
| Analysis | | | |
| % sulfur | Trace | Trace | Trace |
| % ash | Trace | Trace | Trace |
| Heating value, kJ/m^3 (Btu/ ft^3) | 37,218 (1000) | 37,218 (1000) | 37,218 (1000) |
| Excess air, % | 15 | 15 | 15 |
| Flue gas flow rate, m^3/s (acfm) | 0.81 (1700) | 2.45 (5200) | 4.74 (10,100) |
| Flue gas temperature, °K (°F) | 450 (350) | 450 (350) | 450 (350) |
| Load factor, % | 45 | 45 | 45 |
| Utility requirements | | | |
| Electricity, kW | 59 | 114 | 236 |
| Process water, liter/s (gpm) | 0.10 (1.6) | 0.30 (4.8) | 0.60 (9.5) |
| Manpower requirements | | | |
| Direct labor, man-yr | 4 | 4 | 4 |
| Supervision, man-yr | | 2 | 2 |
| Maintenance labor, man-yr | .5 | 1 | 1 |
| Bottom ash disposal requirement, kg/h (ton/h) | Negligible | Negligible | Negligible |

TABLE 14. DESIGN PARAMETERS FOR PACKAGE, WATER-TUBE
BOILERS FIRING RESIDUAL OIL

| | | | | |
|--|---------------------|---------------------|---------------------|---------------------|
| Thermal input , MW (10^6 Btu/h) | 8.8 (30) | 17.6 (60) | 29.3 (100) | 44.0 (150) |
| Fuel | Residual oil | Residual oil | Residual oil | Residual oil |
| Fuel rate, m^3/h (gal/h) | 0.76 (200.3) | 1.52 (400.5) | 2.53 (667.6) | 3.79 (1001.3) |
| Analysis | | | | |
| % sulfur | 3.0 | 3.0 | 3.0 | 3.0 |
| % ash | 0.1 | 0.1 | 0.1 | 0.1 |
| Heating value, MJ/ m^3 (Btu/gal) | 41,714 (149,800) | 41,714 (149,800) | 41,714 (149,800) | 41,714 (149,800) |
| Excess air, % | 15 | 15 | 15 | 15 |
| Flue gas flow rate, m^3/s (acfm) | 4.62 (9800) | 9.25 (19,600) | 15.43 (32,700) | 23.12 (49,000) |
| Flue gas temperature, °K (°F) | 478 (400) | 478 (400) | 478 (400) | 478 (400) |
| Load factor, % | 55 | 55 | 55 | 55 |
| Utility requirements | | | | |
| Electricity, kW | 236 | 265 | 316 | 379 |
| Process water, liter/s (gpm) | 0.61 (9.6) | 1.21 (19.2) | 2.02 (32.0) | 3.03 (48.0) |
| Manpower requirements | | | | |
| Direct labor, man-yr | 4 | 4 | 6 | 8 |
| Supervision, man-yr | 2 | 2 | 2 | 2 |
| Maintenance labor, man-yr | 1 | 2 | 2 | 2 |
| Bottom ash disposal requirement, kg/h (ton/h) | Negligible | Negligible | Negligible | Negligible |

TABLE 15. DESIGN PARAMETERS FOR PACKAGE, WATER-TUBE
BOILERS FIRING DISTILLATE OIL

| | | | | |
|--|---------------------|---------------------|---------------------|---------------------|
| Thermal input, MW (10^6 Btu/h) | 8.8 (30) | 17.6 (60) | 29.3 (100) | 44.0 (150) |
| Fuel | Distillate oil | Distillate oil | Distillate oil | Distillate oil |
| Fuel rate, m^3/h (gal/h) | 0.82 (215.8) | 1.63 (431.7) | 2.72 (719.4) | 4.09 (1080.0) |
| Analysis | | | | |
| % sulfur | 0.5 | 0.5 | 0.5 | 0.5 |
| % ash | Trace | Trace | Trace | Trace |
| Heating value, MJ/ m^3 (Btu/gal) | 38,712 (139,000) | 38,712 (139,000) | 38,712 (139,000) | 38,712 (139,000) |
| Excess air, % | 15 | 15 | 15 | 15 |
| Flue gas flow rate, m^3/s (acfm) | 4.36 (9,240) | 8.73 (18,500) | 14.53 (30,800) | 21.78 (46,200) |
| Flue gas temperature, °K (°F) | 450 (350) | 450 (350) | 450 (350) | 450 (350) |
| Load factor, % | 55 | 55 | 55 | 55 |
| Utility requirements | | | | |
| Electricity, kW | 236 | 265 | 316 | 379 |
| Process water, liters/s (gpm) | 0.61 (9.6) | 1.21 (19.2) | 2.02 (32.0) | 3.03 (48.0) |
| Manpower requirements | | | | |
| Direct labor, man-yr | 4 | 4 | 6 | 8 |
| Supervision, man-yr | 2 | 2 | 2 | 2 |
| Maintenance labor, man-yr | 1 | 2 | 2 | 2 |
| Bottom ash disposal requirement, kg/h (ton/h) | Negligible | Negligible | Negligible | Negligible |

**TABLE 16. DESIGN PARAMETERS FOR PACKAGE, WATER-TUBE
BOILERS FIRING NATURAL GAS**

| | | | | |
|--|--------------------------|--------------------------|---------------------------|---------------------------|
| Thermal input, MW (10^6 Btu/h) | 8.8 (30) | 17.6 (60) | 29.3 (100) | 44.0 (150) |
| Fuel | Natural gas | Natural gas | Natural gas | Natural gas |
| Fuel rate, m^3/s (ft^3/h) | 0.24 (30,000) | 0.47 (60,000) | 0.79 (100,000) | 1.18 (150,000) |
| Analysis | | | | |
| % sulfur | Trace | Trace | Trace | Trace |
| % ash | Trace | Trace | Trace | Trace |
| Heating value, kJ/m^3 (Btu/ ft^3) | 37,218 (1000) | 37,218 (1000) | 37,218 (1000) | 37,218 (1000) |
| Excess air, % | 15 | 15 | 15 | 15 |
| Flue gas flow rate, m^3/s (acfm) | 4.43 (9,380) | 8.87 (18,800) | 14.77 (31,300) | 22.15 (46,900) |
| Flue gas temperature, °K (°F) | 450 (350) | 450 (350) | 450 (350) | 450 (350) |
| Load factor, % | 55 | 55 | 55 | 55 |
| Utility requirements | | | | |
| Electricity, kW | 236 | 265 | 316 | 379 |
| Process water, liters/s (gpm) | 0.61 (9.6) | 1.21 (19.2) | 2.02 (32.0) | 3.03 (48.0) |
| Manpower requirements | | | | |
| Direct labor, man-yr | 4 | 4 | 6 | 8 |
| Supervision, man-yr | 2 | 2 | 2 | 2 |
| Maintenance labor, man-yr | 1 | 2 | 2 | 2 |
| Bottom ash disposal requirement, kg/h (ton/h) | Negligible | Negligible | Negligible | Negligible |

**TABLE 17. DESIGN PARAMETERS FOR FIELD-ERECTED, WATER-TUBE
BOILERS FIRING RESIDUAL OIL**

| | | | |
|--|---------------------|---------------------|---------------------|
| Thermal input, MW (10^6 Btu/h) | 58.6 (200) | 117.2 (400) | 205.1 (700) |
| Fuel | Residual oil | Residual oil | Residual oil |
| Fuel rate, m^3/h (gal/h) | 5.05 (1335.1) | 10.11 (2670.2) | 17.69 (4672.9) |
| Analysis | | | |
| % sulfur | 3.0 | 3.0 | 3.0 |
| % ash | 0.1 | 0.1 | 0.1 |
| Heating value, MJ/ m^3 (Btu/gal) | 41,714 (149,800) | 41,714 (149,800) | 41,714 (149,800) |
| Excess air, % | 15 | 15 | 15 |
| Flue gas flow rate, m^3/s (acfm) | 30.87 (65,400) | 61.73 (130,800) | 108.03 (228,900) |
| Flue gas temperature, °K (°F) | 478 (400) | 478 (400) | 478 (400) |
| Load factor, % | 55 | 55 | 55 |
| Utility requirements | | | |
| Electricity, kW | 569 | 885 | 1453 |
| Process water, liters/s (gpm) | 4.04 (64.0) | 8.08 (128.0) | 14.14 (224.0) |
| Manpower requirements | | | |
| Direct labor, man-yr | 10 | 18 | 23 |
| Supervision, man-yr | 3 | 4 | 4 |
| Maintenance labor, man-yr | 3 | 4 | 7 |
| Bottom ash disposal requirement, kg/h (ton/h) | Negligible | Negligible | Negligible |

TABLE 18. DESIGN PARAMETERS FOR FIELD-ERECTED, WATER-TUBE
BOILERS FIRING DISTILLATE OIL

| | | | |
|--|---------------------|---------------------|---------------------|
| Thermal input, MW (10^6 Btu/h) | 58.6 (200) | 117.2 (400) | 205.1 (700) |
| Fuel | Distillate oil | Distillate oil | Distillate oil |
| Fuel rate, m^3/h (gal/h) | 5.45 (1438.8) | 10.89 (2877.7) | 19.06 (5036.0) |
| Analysis | | | |
| % sulfur | 0.5 | 0.5 | 0.5 |
| % ash | Trace | Trace | Trace |
| Heating value, MJ/ m^3 (Btu/gal) | 38,712 (139,000) | 38,712 (139,000) | 38,712 (139,000) |
| Excess air, % | 15 | 15 | 15 |
| Flue gas flow rate, m^3/s (acfm) | 29.07 (61,600) | 58.14 (123,200) | 101.76 (215,600) |
| Flue gas temperature, °K (°F) | 450 (350) | 450 (350) | 450 (350) |
| Load factor, % | 55 | 55 | 55 |
| Utility requirements | | | |
| Electricity, kW | 569 | 885 | 1453 |
| Process water, liters/s (gpm) | 4.04 (64.0) | 8.08 (128.0) | 14.14 (224.0) |
| Manpower requirements | | | |
| Direct labor, man-yr | 10 | 18 | 23 |
| Supervision, man-yr | 3 | 4 | 4 |
| Maintenance labor, man-yr | 3 | 4 | 7 |
| Bottom ash disposal requirement, kg/h (ton/h) | Negligible | Negligible | Negligible |

TABLE 19. DESIGN PARAMETERS FOR FIELD-ERECTED, WATER-TUBE
BOILERS FIRING NATURAL GAS

| | | | |
|--|-------------------|--------------------|---------------------|
| Thermal input, MW (10^6 Btu/h) | 58.6 (200) | 117.2 (400) | 205.1 (700) |
| Fuel | Natural gas | Natural gas | Natural gas |
| Fuel rate, m ³ /s (ft ³ /h) | 15.7 (200,000) | 3.15 (400,000) | 5.51 (700,000) |
| Analysis | | | |
| % sulfur | Trace | Trace | Trace |
| % ash | Trace | Trace | Trace |
| Heating value, kJ/m ³ (Btu/ft ³) | 37,218 (1000) | 37,218 (1000) | 37,218 (1000) |
| Excess air, % | 15 | 15 | 15 |
| Flue gas flow rate, m ³ /s (acfm) | 29.50 (62,500) | 59.04 (125,100) | 103.31 (218,900) |
| Flue gas temperature, °K (°F) | 450 (350) | 450 (350) | 450 (350) |
| Load factor, % | 55 | 55 | 55 |
| Utility requirements | | | |
| Electricity, kW | 569 | 885 | 1453 |
| Process water, liters/s (gpm) | 4.04 (64.0) | 8.08 (128.0) | 14.14 (224.0) |
| Manpower requirements | | | |
| Direct labor, man-yr | 10 | 18 | 23 |
| Supervision, man-yr | 3 | 4 | 4 |
| Maintenance labor, man-yr | 3 | 4 | 7 |
| Bottom ash disposal requirement, kg/h (ton/h) | Negligible | Negligible | Negligible |

BOILER CONFIGURATION

Boiler configuration was specified as an initial step in the selection of representative boilers.

DESIGN HEAT INPUT RATE

This rate is based on the available capacities of the boilers within the selected configurations. The selection of the capacity range reflects the most common capacities within a particular boiler configuration.

FUEL ANALYSIS

Fuel type for each boiler was chosen as part of the initial selection process. The fuel analyses presented in Table 20 for natural gas, distillate oil, and residual oil were determined from data about "average" fuels presented by Babcock & Wilcox (1972). The Babcock & Wilcox analysis of Birmingham natural gas was selected as average. The values selected for distillate oil represent No. 2 fuel oil; they were selected from the middle of the ranges presented, except for sulfur content, which was selected from the upper part of the range for evaluation of a distillate oil with a relatively high sulfur content. The analysis for the residual oil was selected from the ranges of values given for No. 6 fuel oil; again, all values were taken from the middle of the ranges except the sulfur value, which comes from the upper part of the range so that a high-sulfur residual oil can be evaluated.

TABLE 20. ULTIMATE ANALYSES OF FUELS SELECTED FOR THE BOILERS^a

| Fuel | Composition, % by weight | | | | | | | Heating value, kJ/kg (Btu/lb) |
|---|--------------------------|--------|----------|----------|--------|--------|-------|----------------------------------|
| | Water | Carbon | Hydrogen | Nitrogen | Oxygen | Sulfur | Ash | |
| Natural gas | 0.02 | 69.26 | 22.67 | 8.05 | Trace | Trace | 0 | 50,707 (21,800) |
| Distillate oil | 0.05 | 87.17 | 12.28 | Trace | Trace | 0.50 | Trace | 45,346 (19,500) |
| Residual oil | 0.08 | 86.62 | 10.20 | Trace | Trace | 3.00 | 0.10 | 43,043 (18,500) |
| Eastern high-sulfur, high-ash coal | 8.79 | 64.80 | 4.43 | 1.30 | 6.56 | 3.54 | 10.58 | 27,447 (11,800) |
| Eastern medium-sulfur, high-ash coal | 0.80 | 74.80 | 4.56 | 1.19 | 3.17 | 2.28 | 13.20 | 30,703 (13,200) |
| Eastern low-sulfur, low-ash coal | 2.54 | 78.64 | 4.70 | 1.48 | 4.88 | 0.90 | 6.86 | 32,099 (13,800) |
| Western low-sulfur, low-ash coal | 20.80 | 57.60 | 3.20 | 1.20 | 11.20 | 0.60 | 5.40 | 22,330 (9,600) |

^a All analyses are based on engineering judgments by PEDCo about information from Babcock & Wilcox (1972), except for the analysis of eastern medium-sulfur, high-ash coal, which Versar, Inc., provided in a memo of March 22, 1979, to J. Kilgroe, IERL, Research Triangle Park, North Carolina.

Four coal analyses were used to represent the major coal-producing areas and classes of coals available in the United States. Data from Babcock & Wilcox (1972) served as the basis for the analyses of eastern high-sulfur, high-ash, bituminous coal; eastern low-sulfur, low-ash, low-moisture, bituminous coal; and western low-sulfur, low-ash, high-moisture, subbituminous coal. Versar, Inc. provided the analysis of eastern medium-sulfur, high-ash, low-moisture bituminous coal.

FUEL CONSUMPTION

Given the heat input rate specified for each selected boiler in Table 1, fuel consumption was calculated by dividing the heat input rate by the heating value of the fuel used. For example, if a package, water-tube, underfeed stoker with a heat input rate of 8.8 MW thermal (30×10^6 Btu/h) fires eastern coal at 27,447 kJ/kg, the amount of fuel required is equal to $8800 \text{ kJ/s} \div 27,447 \text{ kJ/kg}$, or 0.32 kg/s.

Because input capacities are specified, it is not necessary to consider the efficiencies of boiler heat transfer or fuel burning.

EXCESS AIR USAGE

The amount of excess air selected for each boiler type is based on practical knowledge of good boiler operating practices. Table 21 presents ranges (percentages by weight) of excess air common to different boiler types. A value for each boiler was

TABLE 21. TYPICAL AMOUNTS OF EXCESS AIR SUPPLIED
TO FUEL-BURNING EQUIPMENT^a

| Fuel | Type of burners | Excess air, % by weight |
|-----------------|---|----------------------------|
| Pulverized coal | Partially water-cooled for dry-ash-removal | 15-40 |
| Coal | Spreader stoker | 30-60 |
| | Chain-grate and traveling-grate stokers | 15-50 |
| | Underfeed stoker | 20-50 |
| Fuel oil | Multifuel and flat-flame | 10-20 |
| Natural gas | Multifuel | 7-15 |

^a Babcock & Wilcox, 1963.

selected out of this range, based upon previous experience and data on boiler operating characteristics.

A mass balance was then performed to obtain the amount of excess air. The combustion air was assumed to have a temperature of 27°C (80°F), a relative humidity of 60 percent, and a pressure of 101 kPa (14.7 psi). The amount of air required for complete combustion of the fuel was calculated on a molal basis from the ultimate analysis of the fuel and the emission rates of the various flue gas constituents.

An example of the procedure is shown below using the package, water-tube, underfeed-stoker boiler with a heat input of 8.8 MW thermal (30×10^6 Btu/h).

The molal configuration for each of the gaseous constituents of the flue gas (determined by emission factors) is calculated by dividing the mass rate by the molecular weight of the constituent. The results for the example boiler are shown below:

| <u>Constituent</u> | <u>moles/h</u> |
|---------------------------------------|----------------|
| Carbon monoxide (CO) | 0.09 |
| Hydrocarbons (as CH ₄) | 0.07 |
| Sulfur dioxide (SO ₂) | 2.80 |
| Nitrogen oxides (as NO ₂) | 0.23 |

The molal rate of each component is then calculated using the fuel mass rate per hour and the ultimate analysis of the fuel. The results for the example boiler are tabulated below:

| <u>Fuel constituent</u> | <u>Mass rate, kg/h (lb/h)</u> | <u>Molal rate</u> |
|----------------------------|-----------------------------------|-------------------|
| Carbon (C) | 12.44 (1646) | 137.1 |
| Hydrogen (H ₂) | 0.85 (113) | 56.1 |
| Sulfur (S) | 0.68 (90) | 2.8 |
| Oxygen (O ₂) | 1.26 (167) | 5.2 |
| Nitrogen (N ₂) | 0.25 (33) | 1.2 |
| Water (H ₂ O) | 1.69 (223) | 12.4 |

The remaining flue gas constituents (CO₂, H₂O, N₂) are calculated by molal balance by subtracting the calculated moles of emissions (U.S. EPA, 1975) from the moles of equivalent components in the fuel. For example, the CO and CH₄ represent part of the carbon from the fuel. Assuming the remaining carbon is oxidized to CO₂, the molal quantity of CO₂ is 137.17 moles of carbon minus 0.09 moles of CO minus 0.07 moles of CH₄ or 137.01 moles of CO₂. The results of similar analyses for the other flue gas constituents of the example boiler are as follows:

| <u>Constituent</u> | <u>Molal quantity</u> |
|--------------------|-----------------------|
| CO ₂ | 137.0 |
| H ₂ O | 68.5 |
| N ₂ | 1.1 |

To calculate the stoichiometric oxygen required, each flue gas constituent is examined in terms of equivalent oxygen content. The following is a presentation of data for the example boiler.

| <u>Flue gas constituent</u> | <u>Moles per hour</u> | <u>Moles of O₂ per mole constituent</u> | <u>Moles of O₂ per hour</u> |
|---------------------------------------|-----------------------|--|--|
| CO ₂ | 137.0 | 1.0 | 137.0 |
| CO | 0.09 | 0.5 | 0.4 |
| CH ₄ | 0.07 | 0.0 | 0.0 |
| SO ₂ | 2.80 | 1.0 | 2.8 |
| H ₂ O | 68.5 | 0.5 | 34.2 |
| NO _x (as NO ₂) | 0.23 | 1 | 0.23 |
| N ₂ | 1.1 | 0.0 | <u>0.0</u> |
| Total | | | 174.27 |

Of the 174.3 moles of O₂ required, the O₂ in the coal supplies 5.2 moles and the H₂O in the coal supplies 6.2 moles. Therefore the theoretical requirement from the combustion air is 162.9 moles of O₂. The excess air for this boiler is 50 percent of stoichiometric. Therefore the total oxygen required is 1.5 times the theoretical requirement, or 244.4 moles. It was assumed that the combustion air is 21 percent oxygen and 79 percent nitrogen. Therefore the N₂ required is 919 moles. The weight of dry air supplied is then 15,256 kg/h (33,564 lb/h). At the previously assumed combustion air conditions, 6.0212 mole of water is contained in the wet air per mole of dry air (24 moles of H₂O total). The total wet combustion air supplied is then 15,453 kg/h (33,996 lb/h).

FLUE GAS CHARACTERISTICS

The volume of the exit flue gas is dependent upon its composition, the amount of excess air, and the exit temperature. The

total moles of the various flue gas constituents was determined for each boiler in the excess air calculations. At standard conditions, the volume of a mole of gas is 10.2 m^3 (359 ft^3), assuming ideal behavior. Therefore the volume of the flue gas at standard conditions can be calculated.

The actual volume of the flue gas must be calculated at the flue gas temperature. Assumed temperatures of the exit flue gas from each boiler were based on typical temperatures from previous boiler studies. The calculated volumes of flue gas were then adjusted from standard conditions to the actual temperature. It was assumed that the flue gas pressure is constant at 101 kPa (14.7 psi).

For example, for a package, water tube, underfeed-stoker boiler with a heat input of 8.8 MW thermal ($30 \times 10^6 \text{ Btu/h}$), total dry flue gas was calculated to be 1135.9 moles. On a wet basis, flue gas was calculated to be 1228.4 moles. At the assumed exhaust temperature of 478°K (400°F) the flue gas volume is:

$$\begin{aligned}
 &1228.4 \text{ moles/h} \times 10.2 \text{ m}^3/\text{mole} \times \frac{478^\circ\text{K}}{273^\circ\text{K}} = \\
 &21,938 \text{ m}^3/\text{h} \text{ (775,204 ft}^3/\text{h)} \\
 &21,938 \text{ m}^3/\text{h} \div 3600 \text{ s/h} = 6.09 \text{ m}^3/\text{s} \text{ (12,900 ft}^3/\text{min)}
 \end{aligned}$$

LOAD FACTOR

Assumed load factors for the boilers were based on ranges of load factors for industrial boilers. Battelle (Locklin, et al., 1974) estimated load factors in industrial/ commercial boilers to range from 30 to 80 percent. Selection of values from the range

for each representative boiler was based on previous boiler studies and data on typical load factors. The load factors are believed to be representative of new industrial boilers supplying process steam.

UTILITY REQUIREMENTS

A boiler facility requires electricity to operate a variety of equipment. The equipment items include fans, controls, pulverizers or stokers, feeders, crushers, conveyors, pumps, compressors, lights, heating equipment, air conditioning, and instrumentation. For each boiler facility an estimate was made of the electrical requirements for these equipment items based on boiler plants of similar size.

Also a boiler requires make-up water to replace that lost in the steam-condensation cycle. For each of the boilers it was assumed that 20 percent of the total water requirement is lost in every condensate cycle.

MANPOWER REQUIREMENTS

The labor required to operate a boiler facility consists of operating labor, supervision, and maintenance labor. The labor requirement is based upon the number of men required to operate the boiler on a continuous (24 hour) basis. The plant is assumed to operate on a three shift basis with each man working the equivalent of 2190 hours per year. The estimates of manpower requirements reflect a conservative case with state laws that

require an operator at all times for a boiler facility taken into account. A less conservative approach could reduce these labor requirements to some extent and in cases of multiple boilers at a single site, the requirement would be significantly reduced.

BOTTOM ASH DISPOSAL REQUIREMENT

For coal-fired boilers the bottom ash disposal requirement is calculated based upon the fly ash emission factors presented in AP-42 (U.S. EPA, 1977). For each type of boiler, the percent bottom ash is as follows:

| <u>Coal-firing mechanism</u> | <u>Percent bottom ash</u> |
|------------------------------|---------------------------|
| Pulverizer | 20 |
| Spreader stoker | 35 |
| Overfeed stoker | 35 |
| Chain grate stoker | 75 |
| Underfeed stoker | 75 |
| Other stokers | 75 |

The hourly rate of bottom ash is calculated as follows:

$$\text{Bottom ash (tons/h)} = \text{Coal feed (tons/h)} \times \frac{\% \text{ ash}}{100} \times \frac{\% \text{ bottom ash}}{100}$$

For example, for the 8.8 MW thermal (30×10^6 Btu/h) package water-tube underfeed stoker boiler firing eastern high-sulfur coal the bottom ash rate is:

$$\begin{aligned} \text{Bottom ash} &= (1.27 \text{ ton/h}) (10.6 \div 100) (75 \div 100) \\ &= 0.10 \text{ ton/h} \end{aligned}$$

REFERENCES FOR SECTION 2

- Babcock & Wilcox. 1963. Steam - Its Generation and Use, Thirty-seventh Edition. New York City.
- Babcock & Wilcox. 1972. Useful Tables for Engineers and Steam Users, Twelfth Edition. New York City.
- Locklin, D.W., H.H. Krause, A.A. Putnam, E.L. Kropp, W.T. Reid, and M.A. Duffy. 1974. Design Trends and Operating Problems in Combustion Modification of Industrial Boilers. EPA R-802402, Battelle-Columbus Laboratories, Columbus, Ohio.
- U.S. EPA. 1977. Compilation of Air Pollutant Emission Factors, AP-42, Third Edition.

3.0 COST ESTIMATES FOR NEW BOILERS

Estimates were developed for the cost of new installations of the boilers described in Section 2. An outline of the procedures used in developing the costs is followed by the cost estimates.

COST ESTIMATING PROCEDURE

Cost of a boiler facility includes the costs of basic equipment, the costs of installation, and the costs of operating and maintaining the boiler. A capital cost estimate is developed by the following steps:

- ° Define the battery limits of the facility.
- ° Develop a list of equipment required.
- ° Obtain prices for each equipment item.
- ° Calculate installation costs.
- ° Calculate indirect capital costs.

Costs are all-inclusive, accounting for the material and labor needed to complete an operational boiler plant. The estimates were prepared from a detailed equipment summary. Estimates of erection costs are based on experience and on actual cost of erection at similar plants.

Battery limits of the facility extend from the fuel-receiving equipment to the ash disposal site, inclusively. Excluded are

steam and condensate piping beyond the boiler building and pollution control equipment. Costs of ducting and the stack are included.

Based on guidelines presented by H.K. Ferguson (Coffin, 1978), an equipment list was developed for each boiler. The major equipment items are described below.

Water enters the system through a treatment process--for this study a standard Zeolite softening system. The makeup water is then fed to a deaerator, which has a 15-minute holding capacity at full flow. The return condensate is piped to the condensate return tank. It is assumed that 20 percent makeup is required. The overflow storage tank for the condensate return tank is sized to hold the condensate generated in 1 hour at full load capacity.

A continuous-blowdown flash tank and drain heat recovery system recover all available heat from both the flash steam and the drains.

Two boiler feed pumps are provided, 100 percent capacity each. Automatic recirculation shutoff is not included. A fixed minimum-flow bypass orifice is used for simplicity.

Each oil-fired boiler has 100 percent Maximum Capacity Rating (MCR) oil-burning capability and includes a storage tank and transfer pump facility. In the plant, a pump and heater set are provided, consisting of two pumps (100 percent capacity) for firing of No. 6 oil. Capacity of the storage tank provides approximately 7 days firing at MCR.

Coal is stored in the plant in overhead bunkers supported by the building steel. Coal is loaded into the bunkers by a conveying system designed to fill the bunkers completely during an 8-hour shift. Bunker capacity is sufficient to operate the plant for 24 hours at full load.

The conveying system includes the under-track hopper, which supplies a coal silo with 10 days' storage; a bucket elevator or belt conveyor, depending on building height (100 ft maximum for a bucket elevator); and an over-bunker tripper conveyor to load each bunker section. A crusher included with the hopper allows some sizing of the coal feed.

The stoker-fired plants include an under-bunker conveyor, tripper mechanism, and a nonsegregating conical distributor to the stoker hopper.

The pulverized-coal-fired plant includes gravimetric feeders to the pulverizers.

Ash handling systems of the pneumatic type (dry) transport fly ash and bottom ash to a temporary storage silo for later removal by truck. The bottom ash handling equipment includes a clinker breaker.

Except for the pulverized-coal-fired boiler, which requires an air heater to dry the coal sufficiently, all boilers are equipped with economizers.

Controls are provided to regulate combustion, feedwater, and flame safety. The pulverized-coal-fired boiler also has an electronic pulverizer control system for safe and reliable starting of the pulverizers.

The building, constructed of insulated steel, includes a small office area and employees' washroom. No provision is made for an enclosed control room for the operators; rather, the boiler control panels are free-standing in front of the boiler firing aisle. Lighting, ventilation, ladders, gratings, and painting are included.

A 1 to 2 acre parcel of land is allocated to each of the boilers. Table 22 lists the basic equipment and installation items included in the capital cost estimates. Table 23 lists the sources of data used in estimating capital costs. Costs were obtained for the low-sulfur bituminous coal; costs were then apportioned to the subbituminous, medium-sulfur, and high-sulfur bituminous coals by use of factors obtained from boiler manufacturers. Indirect capital costs were estimated as a percentage of the installed equipment costs. Table 24 lists the percentages used for each item.

The costs are based on a Greenfield boiler installation with no pollution control equipment, located in the Midwest. Regional cost factors may be used to estimate costs in areas other than the Midwest. The costs were adjusted to June 30, 1978.

Annual operating and maintenance costs are based on requirements for labor, materials, and utilities as cited by manufacturers of boilers and auxiliary equipment and presented in Section 2, together with the unit costs specified for the Midwest in Table 25.

TABLE 22. BASIC EQUIPMENT AND INSTALLATION ITEMS INCLUDED
IN A NEW BOILER FACILITY

Equipment:

Boiler (with fans and ducts)
Stack
Instrumentation
Pulverizers or Stoker system
Feeders
Crushers
Deaerator
Heaters
Boiler feed pumps
Condensate systems
Water treating system
Chemical feed
Compressed air system
Coal handling system
Ash disposal system
Thawing equipment
Fuel oil system

Installation:

Foundations and supports
Piping
Insulation
Painting
Electrical
Building

TABLE 23. SOURCES OF COST DATA FOR EQUIPMENT AND INSTALLATION
ITEMS INCLUDED IN BOILER PLANTS

| Equipment item | Sources of cost data |
|------------------------------|--|
| Boiler (with fans and ducts) | Babcock & Wilcox Co. Combustion Engineering, Inc. Cleaver-Brooks Division of Aqua-Chem Erie City Energy Division of Zurn E. Keeler Co. |
| Stacks | Airtek Rust Engineering Richardson Cost Estimating Manual ^a |
| Instrumentation | Aedes Associates, Inc. Babcock & Wilcox Co. Combustion Engineering, Inc. Cleaver-Brooks Division of Aqua-Chem Erie City Energy Division of Zurn E. Keeler Co. |
| Pulverizers or stoker system | Babcock & Wilcox Co. Combustion Engineering, Inc. Cleaver-Brooks Division of Aqua-Chem Erie City Energy Division of Zurn E. Keller Co. |
| Feeders | Jeffrey Manufacturing Co. Babcock & Wilcox Co. Combustion Engineering, Inc. Cleaver-Brooks Division of Aqua-Chem Erie City Energy Division of Zurn E. Keeler Co. |
| Crushers | Pennsylvania Crusher Co. Richardson Cost Estimating Manual ^a |
| Deaerator | Chicago Heater Co. Cochrane Environmental Systems |
| Heaters | Richardson Cost Estimating Manual |
| Boiler feed pumps | Ingersoll-Rand Richardson Cost Estimating Manual ^a Richardson Cost Estimating Manual ^a |

(continued)

TABLE 23. (continued)

| Equipment items | Sources of cost data |
|--------------------------|--|
| Condensate system | Richardson Cost Estimating Manual ^a |
| Water treatment system | Crane Cochran Zeolite Calgon Corp. |
| Chemical feed | Milton Roy Co. Richardson Cost Estimating Manual ^a |
| Compressed air system | Ingersoll-Rand Richardson Cost Estimating Manual ^a |
| Coal handling system | Jeffrey Manufacturing Co. Caterpillar Co. Richardson Cost Estimating Manual ^a |
| Ash disposal system | Allen-Sherman-Hoff, Inc. United Conveyor Richardson Cost Estimating Manual ^a |
| Thawing equipment | Aedes Associates, Inc. |
| Fuel oil system | Coen Co. Aedes Associates, Inc. |
| Foundations and supports | Aedes Associates, Inc. |
| Piping | Aedes Associates, Inc. |
| Insulation | Aedes Associates, Inc. |
| Painting | Aedes Associates, Inc. |
| Electrical | Aedes Associates, Inc. |
| Building | Aedes Associates, Inc. |

^a Richardson, 1978.

Table 24. TYPICAL VALUES^a FOR INDIRECT CAPITAL COSTS

| Cost item | Range of values |
|---------------------------------|---|
| Engineering | 8 to 20 percent of installed cost. High value for small projects; low value for large projects. <u>Recommend 10 percent</u> |
| Construction and field expenses | 7 to 20 percent of installed cost. <u>Recommend 10 percent</u> |
| Contractor's fee | 10 to 15 percent of installed cost. <u>Recommend 10 percent</u> |
| Shakedown | 1 to 6 percent of installed cost. <u>Recommend 2 percent</u> |
| Performance test | Minimum value of \$2000. |
| Contingency | 10 to 30 percent of total direct and indirect costs dependent upon accuracy of estimate. <u>Recommend 20 percent</u> |
| Working capital | 15 to 35 percent of the total annual operation and maintenance costs. <u>Recommend 25 percent</u> |

^a Devitt, 1979.

TABLE 25. ANNUAL UNIT COSTS FOR OPERATION AND MAINTENANCE
(June 1978 dollars)

| Cost factors | Recommended value |
|--|--------------------|
| Direct labor, \$/man-hour | 12.02 ^a |
| Supervision, \$/man-hour | 15.63 ^b |
| Maintenance labor, \$/man-hour | 14.63 ^a |
| Electricity, mills/kWh | 25.80 ^c |
| Process water, \$/10 ³ gal | 0.15 ^d |
| Coal, \$/10 ⁶ Btu | |
| Eastern high-sulfur | 0.74 ^e |
| Eastern medium-sulfur | 0.95 ^f |
| Eastern low-sulfur | 1.16 ^e |
| Subbituminous | 0.42 ^e |
| No. 2 fuel oil, \$/10 ⁶ Btu | 3.00 ^g |
| No. 6 fuel oil, \$/10 ⁶ Btu | 2.21 ^g |
| Natural gas, \$/10 ⁶ Btu | 1.95 ^h |
| Bottom ash disposal, \$/ton | 40.00 ⁱ |

^a Engineering News-Record, June 29, 1978, pp. 52-52. Average for Chicago, Cincinnati, Cleveland, Detroit, and St. Louis.

^b Estimated at 30 percent over direct labor rate.

^c EEI members publication for June, 1978. Average for Boston, Chicago, Indianapolis, Houston, San Francisco, and Los Angeles.

^d Peters, M.S., and K.D. Timmerhaus. Plant Design and Economics for Chemical Engineers, 2nd Edition. McGraw-Hill Book Co. New York 1968. p. 772. Adjusted to 1978 prices using Nelson Refinery Operating Cost Indexes for Chemicals. July 1978.

^e Coal Outlook, July 18, 1978. Spot market prices.

^f Average of prices for high- and low-sulfur coal.

^g Electrical Week, May issues, 1978. Spot market prices.

^h Gas Facts, 1977. American Gas Association. Average U.S. price.

ⁱ Based on \$2/ton-mile and disposal site 20 miles from plant.

Table 26 lists the elements of annual operating and maintenance costs; Table 27 indicates the methods used in developing the costs; the boiler parameter tables (Tables 2 through 19) show the manpower requirements on which the labor costs are based.

The cost of disposing of bottom ash from a coal-fired boiler is based on a 32-km (20-mi) one-way haul to ultimate disposal in an environmentally sound landfill. The bottom ash is assumed to be wetted to 20 percent moisture and hauled in covered trucks. The disposal cost components include truck loading, washing the loaded trucks, truck transportation, road cleaning and repair, truck unloading, washing the unloaded trucks, and landfill fees, including treatment. The ash disposal operation is conducted by an outside contracting firm rather than the company itself. The waste disposal cost is estimated at \$44/Mg (\$40/ton). This is a conservative estimate of the average cost for a typical industrial boiler with a heat input of about 30 MW thermal (100×10^6 Btu/h). Although the waste disposal cost can vary greatly depending upon the haul distance and the method of disposal, this conservative estimate reflects good environmental practice.

Another component of operating cost is overhead, which represents a business expense that is not charged directly to a particular part of the process but is allocated to it. Overhead costs include administrative, safety, engineering, legal, and medical services; payroll expenses including FICA; employee benefits; and public relations. Overhead costs are usually

TABLE 26. DIRECT ANNUAL OPERATION AND MAINTENANCE COST ITEMS
ASSOCIATED WITH BOILERS

| |
|-------------------|
| Operational labor |
| Supervision |
| Maintenance labor |
| Replacement parts |
| Electricity |
| Process water |
| Fuel |
| Waste disposal |
| Chemicals |

TABLE 27. METHODS USED TO ESTIMATE DIRECT ANNUAL COSTS

| Cost item | Method of obtaining cost |
|-----------------------------|--|
| Operational labor | Multiply manpower requirements from parameter tables by rate given in Table 25. |
| Supervision | Multiply manpower requirements from parameter tables by rate given in Table 25. |
| Maintenance labor | Multiply manpower requirements from parameter tables by rate given in Table 25. |
| Replacement parts | Aedes Associates, Inc. determined percentages of total equipment cost based on actual jobs (8 to 21%). |
| Electricity | Based on major equipment and lighting loads. |
| Oil or gas-fired boilers | 59 to 1453 kW |
| Stoker units | 162 to 1001 kW |
| Pulverized-coal-fired units | 1754 to 8920 kW |
| | Multiply kW by operating hours to obtain annual kWh. Multiply annual kWh by electric rate given in Table 25. |
| Process water | Requirement calculated assuming 80 percent return of condensate (20% make-up). Multiply annual usage by water rate given in Table 25. |
| Fuel | Fuel requirement calculated based on design heat input multiplied by hours per year operated based on load factors given in Tables 2 to 19. Multiply annual fuel requirement by appropriate rate from Table 25. |
| Waste disposal | Requirement calculated from total ash in fuel minus the quantity emitted as fly ash. Multiply the annual quantity of wash by an average cost of \$40/ton for disposal in an environmentally sound landfill 20 miles from the plant site. |
| Chemicals | Requirement calculated assuming constant water quality and 80 percent return of condensate (20% make-up). Multiply amount of chemicals used by average costs obtained from chemical suppliers. |

presented as payroll overhead and plant overhead. Following are the values used for each:

Payroll overhead = 30 percent of operating labor

Plant overhead = 26 percent of labor and materials.

The capital investment in a boiler is generally translated into annual capital charges. These charges, along with the annual operating costs, represent the total annualized cost of a boiler.

EPA classifies annual capital-related charges for cost purposes under the following components: general and administrative costs, taxes, insurance; a capital-recovery factor, which represents a levelized principal and interest payment; and interest on working capital. The first three components are set at a total of 4 percent of depreciable investment. The capital-recovery factor was determined at 10 percent interest over the life of a facility.

Capital recovery factors are based on the following boiler life expectancies:

| <u>Boiler type</u> | <u>Expected life, years</u> |
|--------------------------|---------------------------------|
| Package Scotch fire-tube | 20 |
| Package water-tube | 30 |
| Field-erected water-tube | 45 |

From these values for boiler life and the assumed interest rate of 10 percent, the capital recovery factors calculated for each boiler type are as follows:

| <u>Boiler type</u> | <u>Capital recovery factor, %</u> |
|--------------------------|---------------------------------------|
| Package Scotch fire-tube | 11.75 |
| Package water-tube | 10.61 |
| Field-erected water-tube | 10.14 |

COST ESTIMATES

Costs are estimated for all 59 of the typical boilers identified in Section 2. The basic boiler costs were obtained as verbal or written quotations from various boiler manufacturers including Babcock and Wilcox; Cleaver Brooks; Zurn Industries, Inc.; Erie City; and Combustion Engineering. Capital cost estimates for auxiliary equipment (e.g., water treatment systems) are based on quotations obtained from manufacturers in related projects.

The estimated costs are summarized in Table 28 for the package water-tube underfeed-stoker boilers firing the four different coal types. Detailed cost breakdowns for each of these boilers are presented in Appendix A.

The estimated costs are summarized for field-erected water-tube spreader-stoker boilers firing the four coal types in Table 29. The detailed costs are presented in Appendix A.

Table 30 summarizes the estimated costs of field-erected water-tube, pulverized-coal-fired boilers. Detailed cost breakdowns are presented in Appendix A.

The estimated costs for package fire-tube boilers are summarized in Table 31 with the detailed costs presented in Appendix B.

TABLE 28. ESTIMATED CAPITAL AND ANNUALIZED COSTS OF PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILERS FIRING COAL

| Size, MW (10 ⁶ Btu/h) | Coal | Capital costs Grand total, \$ | Annualized costs | | | | Parameter table No. | Cost table |
|-------------------------------------|-----------------------|----------------------------------|---|-------------------|------------------------|-----------|------------------------|---------------|
| | | | Direct cost plus overhead less fuel, \$ | Fuel Costs, \$ | Capital charges, \$ | Total, \$ | | |
| 4.4 (15) | Eastern high-sulfur | 1,245,000 | 469,900 | 58,300 | 176,900 | 705,100 | 2 | A-1, A-2 |
| 4.4 (15) | Eastern low-sulfur | 1,094,600 | 453,300 | 91,500 | 154,700 | 699,500 | 2 | A-3, A-4 |
| 4.4 (15) | Subbituminous | 1,487,300 | 485,100 | 33,100 | 212,500 | 730,700 | 2 | A-5, A-6 |
| 4.4 (15) | Eastern medium-sulfur | 1,133,200 | 462,800 | 74,900 | 160,500 | 698,200 | 2 | A-7, A-8 |
| 8.8 (30) | Eastern high-sulfur | 1,891,300 | 565,800 | 116,700 | 269,800 | 952,300 | 3 | A-9, A-10 |
| 8.8 (30) | Eastern low-sulfur | 1,665,200 | 538,700 | 182,900 | 236,300 | 957,900 | 3 | A-11, A-12 |
| 8.8 (30) | Subbituminous | 2,257,100 | 587,100 | 66,200 | 323,600 | 976,900 | 3 | A-13, A-14 |
| 8.8 (30) | Eastern medium-sulfur | 1,723,000 | 554,000 | 149,800 | 244,900 | 948,700 | 3 | A-15, A-16 |
| 17.6 (60) | Eastern high-sulfur | 3,021,800 | 847,000 | 233,400 | 431,100 | 1,511,500 | 4 | A-17, A-18 |
| 17.6 (60) | Eastern low-sulfur | 2,670,700 | 802,000 | 365,800 | 378,600 | 1,546,400 | 4 | A-19, A-20 |
| 17.6 (60) | Subbituminous | 3,594,100 | 873,400 | 132,500 | 515,600 | 1,521,500 | 4 | A-21, A-22 |
| 17.6 (60) | Eastern medium-sulfur | 2,758,100 | 832,000 | 299,600 | 391,900 | 1,523,500 | 4 | A-23, A-24 |

TABLE 29. ESTIMATED CAPITAL AND ANNUALIZED COSTS OF FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILERS FIRING COAL

| Size, MW (10 ⁶ Btu/h) | Coal | Capital costs Grand total, \$ | Annualized costs | | | | Parameter table No. | Cost table |
|-------------------------------------|-----------------------|----------------------------------|---|-------------------|------------------------|-----------|------------------------|---------------|
| | | | Direct cost plus overhead less fuel, \$ | Fuel Costs, \$ | Capital charges, \$ | Total, \$ | | |
| 22.0 (75) | Eastern high-sulfur | 4,587,700 | 898,800 | 291,700 | 638,300 | 1,828,800 | 5 | A-25, A-26 |
| 22.0 (75) | Eastern low-sulfur | 4,064,200 | 858,500 | 457,300 | 563,100 | 1,878,900 | 5 | A-27, A-28 |
| 22.0 (75) | Subbituminous | 5,440,700 | 935,600 | 165,600 | 760,000 | 1,861,200 | 5 | A-29, A-30 |
| 22.0 (75) | Eastern medium-sulfur | 4,192,200 | 878,800 | 374,500 | 581,700 | 1,835,000 | 5 | A-31, A-32 |
| 44.0 (150) | Eastern high-sulfur | 8,784,200 | 1,265,700 | 583,400 | 1,225,900 | 3,075,000 | 6 | A-33, A-34 |
| 44.0 (150) | Eastern low-sulfur | 7,804,100 | 1,187,300 | 914,500 | 1,084,500 | 3,186,300 | 6 | A-35, A-36 |
| 44.0 (150) | Subbituminous | 10,395,800 | 1,334,300 | 331,100 | 1,455,700 | 3,121,100 | 6 | A-37, A-38 |
| 44.0 (150) | Eastern medium-sulfur | 8,041,900 | 1,229,000 | 749,000 | 1,119,500 | 3,097,500 | 6 | A-39, A-40 |
| 58.6 (200) | Eastern high-sulfur | 10,510,200 | 1,641,000 | 777,900 | 1,465,000 | 3,883,900 | 7 | A-41, A-42 |
| 58.6 (200) | Eastern low-sulfur | 9,355,200 | 1,541,900 | 1,219,400 | 1,298,000 | 4,059,300 | 7 | A-43, A-44 |
| 58.6 (200) | Subbituminous | 12,411,400 | 1,731,700 | 441,500 | 1,736,500 | 3,909,700 | 7 | A-45, A-46 |
| 58.6 (200) | Eastern medium-sulfur | 9,637,500 | 1,596,200 | 998,600 | 1,339,700 | 3,934,500 | 7 | A-47, A-48 |

TABLE 30. ESTIMATED CAPITAL AND ANNUALIZED COSTS OF FIELD-ERECTED, WATER-TUBE, PULVERIZED-COAL-FIRED BOILERS

| Size, MW (10 ⁶ Btu/h) | Coal | Capital costs Grand total, \$ | Annualized costs | | | | Parameter table No. | Cost table |
|-------------------------------------|-----------------------|----------------------------------|---|-------------------|------------------------|------------|------------------------|---------------|
| | | | Direct cost plus overhead less fuel, \$ | Fuel Costs, \$ | Capital charges, \$ | Total, \$ | | |
| 58.6 (200) | Eastern high-sulfur | 12,202,400 | 1,766,900 | 777,900 | 1,702,900 | 4,247,700 | 8 | A-49, A-50 |
| 58.6 (200) | Eastern low-sulfur | 10,823,200 | 1,656,200 | 1,219,400 | 1,504,400 | 4,380,000 | 8 | A-51, A-52 |
| 58.6 (200) | Subbituminous | 14,468,400 | 1,901,500 | 441,500 | 2,025,600 | 4,368,600 | 8 | A-53, A-54 |
| 58.6 (200) | Eastern medium-sulfur | 11,161,500 | 1,701,400 | 998,600 | 1,554,100 | 4,254,100 | 8 | A-55, A-56 |
| 117.2 (400) | Eastern high-sulfur | 22,638,000 | 3,068,300 | 1,555,800 | 3,159,500 | 7,783,600 | 9 | A-57, A-58 |
| 117.2 (400) | Eastern low-sulfur | 20,094,000 | 2,878,200 | 2,438,800 | 2,792,500 | 8,109,500 | 9 | A-59, A-60 |
| 117.2 (400) | Subbituminous | 26,836,600 | 3,288,800 | 883,000 | 3,758,200 | 7,930,000 | 9 | A-61, A-62 |
| 117.2 (400) | Eastern medium-sulfur | 20,707,300 | 2,960,700 | 1,997,000 | 2,883,000 | 7,840,700 | 9 | A-63, A-64 |
| 205.1 (700) | Eastern high-sulfur | 36,490,200 | 4,200,000 | 2,722,600 | 5,096,800 | 12,019,400 | 10 | A-65, A-66 |
| 205.1 (700) | Eastern low-sulfur | 32,369,200 | 3,912,500 | 4,267,900 | 4,500,900 | 12,681,300 | 10 | A-67, A-68 |
| 205.1 (700) | Subbituminous | 43,060,300 | 4,509,900 | 1,545,300 | 6,035,000 | 12,090,200 | 10 | A-69, A-70 |
| 205.1 (700) | Eastern medium-sulfur | 33,302,400 | 4,044,300 | 3,495,200 | 4,639,500 | 12,179,000 | 10 | A-71, A-72 |

TABLE 31. ESTIMATED CAPITAL AND ANNUALIZED COSTS OF PACKAGE, FIRE-TUBE BOILERS

| Size MW (10 ⁶ Btu/h) | Fuel | Capital costs grand total, \$ | Annualized costs | | | | Parameter table No. | Cost table |
|------------------------------------|----------------|----------------------------------|--|------------------|------------------------|-----------|------------------------|---------------|
| | | | Direct cost plus overhead less fuel, \$ | Fuel cost, \$ | Capital charges, \$ | Total, \$ | | |
| 1.5 (5) | Residual oil | 243,700 | 201,300 | 43,600 | 35,500 | 280,400 | 11 | B-1, B-2 |
| 4.4 (15) | Residual oil | 404,200 | 322,400 | 130,700 | 58,100 | 511,200 | 11 | B-3, B-4 |
| 8.5 (29) | Residual oil | 602,500 | 347,800 | 252,600 | 87,200 | 687,600 | 11 | B-5, B-6 |
| 1.5 (5) | Distillate oil | 241,800 | 201,300 | 59,100 | 34,900 | 295,300 | 12 | B-7, B-8 |
| 4.4 (15) | Distillate oil | 404,800 | 322,400 | 177,400 | 57,600 | 557,400 | 12 | B-9, B-10 |
| 8.5 (29) | Distillate oil | 610,900 | 347,800 | 343,000 | 87,300 | 778,100 | 12 | B-11, B-12 |
| 1.5 (5) | Natural gas | 236,600 | 201,300 | 38,400 | 34,400 | 274,100 | 13 | B-13, B-14 |
| 4.4 (15) | Natural gas | 389,300 | 322,400 | 115,300 | 56,000 | 493,700 | 13 | B-15, B-16 |
| 8.5 (29) | Natural gas | 580,900 | 347,800 | 222,900 | 84,300 | 655,000 | 13 | B-17, B-18 |

Estimated costs of dual-fuel water-tube boilers firing residual oil/natural gas are summarized in Table 32 with detailed costs presented in Appendix C. Table 33 summarizes the estimated costs of dual-fuel water-tube boilers firing distillate oil/natural gas. Detailed costs are presented in Appendix C.

TABLE 32. ESTIMATED CAPITAL AND ANNUALIZED COSTS OF DUAL-FUEL, WATER-TUBE BOILERS FIRING RESIDUAL OIL/NATURAL GAS

| Boiler type | Size, MW (10 ⁶ Btu/h) | Capital costs | Annualized costs | | | | Parameter tables (oil/gas) | Cost tables |
|---------------|-------------------------------------|------------------------------|--|-----------------------------|----------------------------------|---------------------------|-------------------------------|-------------|
| | | Grand total, \$ (oil/gas) | Direct cost plus overhead less fuel, \$ (oil/gas) | Fuel Costs, \$ (oil/gas) | Capital charges, \$ (oil/gas) | Total, \$ (oil/gas) | | |
| Package | 8.8 (30) | 802,900/ 793,500 | 359,400 | 319,400/ 281,900 | 110,300/ 109,300 | 789,100/ 750,600 | 14/16 | C-1, C-2 |
| Package | 17.6 (60) | 1,230,500/ 1,211,700 | 420,200 | 638,900/ 563,700 | 168,500/ 166,600 | 1,227,600/ 1,150,500 | 14/16 | C-3, C-4 |
| Package | 29.3 (100) | 1,734,000/ 1,702,700 | 520,800 | 1,064,800/ 939,500 | 236,300/ 233,200 | 1,821,900/ 1,693,500 | 14/16 | C-5, C-6 |
| Package | 44.0 (150) | 2,276,600/ 2,229,600 | 625,900 | 1,597,200/ 1,409,300 | 308,600/ 303,900 | 2,531,700/ 2,339,100 | 14/16 | C-7, C-8 |
| Field-erected | 58.6 (200) | 7,412,000/ 7,349,300 | 868,100 | 2,129,600/ 1,879,000 | 1,019,100/ 1,012,900 | 4,016,800/ 3,760,000 | 17/19 | C-9, C-10 |
| Field-erected | 117.2 (400) | 13,225,900/ 13,100,600 | 1,393,700 | 4,259,100/ 3,758,000 | 1,815,300/ 1,802,800 | 7,468,100/ 6,954,500 | 17/19 | C-11, C-12 |
| Field-erected | 205.1 (700) | 21,331,400/ 21,112,200 | 1,898,300 | 7,453,400/ 6,576,600 | 2,924,300/ 2,902,400 | 12,276,000/ 11,377,300 | 17/19 | C-13, C-14 |

TABLE 33. ESTIMATED CAPITAL AND ANNUALIZED COSTS OF DUAL-FUEL, WATER-TUBE BOILERS FIRING DISTILLATE OIL/NATURAL GAS

| Boiler type | Size, MW (10 ⁶ Btu/h) | Capital costs Grand total, \$ (oil/gas) | Annualized costs | | | | Parameter tables (oil/gas) | Cost tables |
|---------------|-------------------------------------|---|--|-----------------------------|----------------------------------|---------------------------|-------------------------------|-------------|
| | | | Direct cost plus overhead less fuel, \$ (oil/gas) | Fuel Costs, \$ (oil/gas) | Capital charges, \$ (oil/gas) | Total, \$ (oil/gas) | | |
| Package | 8.8 (30) | 817,200/ 779,300 | 359,400 | 433,600/ 281,900 | 111,000/ 107,200 | 904,000/ 748,500 | 15/16 | C-15, C-16 |
| Package | 17.6 (60) | 1,267,000/ 1,191,100 | 420,200 | 867,200/ 563,700 | 171,200/ 163,600 | 1,458,600/ 1,147,500 | 15/16 | C-17, C-18 |
| Package | 29.3 (100) | 1,806,500/ 1,680,000 | 520,800 | 1,445,400/ 939,500 | 242,600/ 229,900 | 2,208,800/ 1,690,200 | 15/16 | C-19, C-20 |
| Package | 44.0 (150) | 2,393,900/ 2,204,200 | 625,900 | 2,168,100/ 1,409,300 | 319,200/ 300,200 | 3,113,200/ 2,335,400 | 15/16 | C-21, C-22 |
| Field-erected | 58.6 (200) | 7,483,500/ 7,230,500 | 868,100 | 2,890,800/ 1,879,000 | 1,021,300/ 996,000 | 4,780,200/ 3,743,100 | 18/19 | C-23, C-24 |
| Field-erected | 117.2 (400) | 13,379,900/ 12,874,000 | 1,393,700 | 5,781,600/ 3,758,800 | 1,821,300/ 1,770,700 | 8,996,600/ 6,922,400 | 18/19 | C-25, C-26 |
| Field-erected | 205.1 (700) | 21,609,400/ 20,724,100 | 1,898,300 | 10,117,800/ 6,576,600 | 2,935,900/ 2,847,400 | 14,952,000/ 11,322,300 | 18/19 | C-27, C-28 |

REFERENCES FOR SECTION 3

- Coffin, B.D. 1978. Costing Examples of Industrial Applications, coal-fired Boiler Plants. H.K. Ferguson Co., Cleveland, Ohio.
- Richardson Engineering Services, Inc. 1978. Process Plant Construction Estimating and Engineering Standards. Solana Beach, California.
- Devitt, T., P. Spaite, and L. Gibbs. 1979. The Population and Characteristics of Industrial/Commercial Boilers. PEDCo Environmental, Inc., Cincinnati, Ohio.

4.0 EQUATIONS FOR BOILER COSTS

In order to obtain costs for use by OAQPS in the overall economic evaluation of various regulatory options on new boiler installations, it was necessary to develop relationships between boiler capacity, fuel, and costs. In this task, equations were developed to describe the costs of package fire-tube boilers firing a variety of fuels, package water-tube boilers firing a variety of fuels, and field-erected water-tube boilers also firing a variety of fuels. The following sections present the methodology used in deriving these equations and the results of the analysis.

METHODOLOGY

The basic steps involved in deriving new boiler cost equations were:

- Detailed cost estimates
- Segmenting costs into appropriate categories
- Plotting costs versus input capacity
- Determination of cost equation form
- Derivation of cost equation

Detailed Cost Estimates

Detailed cost estimates were made for the 51 boiler/fuel/capacity combinations described previously. In addition, from previous work, 8 detailed cost estimates were available.

Segmenting Costs Into Appropriate Categories

In this study, equations were to be derived to describe five major components of costs including equipment cost, direct installation costs, indirect installation costs, variable annual operating and maintenance costs, and nonvariable annual operating costs.

The equipment cost, direct installation costs, and indirect installation costs are presented as subtotals in each detailed boiler cost breakdown. Table 34 lists all items included in each subtotal. Note that contingencies, land, and working capital have been excluded from the cost equations. This allows the reader to use site-specific values. For the coal-fired boilers, some of the equipment and direct installation cost items also vary dependent upon the type of coal being burned. Table 34 also indicates the items which vary with coal types.

The direct cost and overhead components of annual cost were classified as either variable (dependent upon the period of time the boiler operated) or non-variable (independent of boiler operational time). Table 35 shows the items classified as variable or nonvariable. It should be noted that although fuel is shown as a variable cost item, for purposes of this study this cost was excluded from the cost equations because the fuel cost can be calculated separately as a direct product of fuel price and fuel usage. Capital charges have also been excluded.

Plotting Costs Versus Input Capacity

The next step was to plot the costs in each category against boiler input capacity by major boiler type/fuel classification. For example, equipment costs for the three residual oil-fired fire-tube boilers were plotted against the appropriate heat input

TABLE 34. FORMAT FOR PRESENTATION OF CAPITAL COSTS
OF INDUSTRIAL BOILERS

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST

| | |
|----------------------------|----------|
| Boiler (with fans & ducts) | Variable |
| Stack | |
| Instrumentation | |
| Pulverizers or stokers | Variable |
| Feeders | Variable |
| Crushers | Variable |
| Deaerators | |
| Heaters | |
| Boiler feed pumps | |
| Condensate systems | |
| Water treating system | |
| Chemical feed | |
| Compressed air system | Variable |
| Coal handling system | Variable |
| Ash disposal system | Variable |
| Thawing equipment | |
| Fuel-oil system | |

Total Equipment Cost

INSTALLATION COST, DIRECT

| | |
|---|----------|
| Boiler (including founda- tions and steel) | Variable |
| Stack | |
| Instrumentation | |
| Pulverizers | Variable |
| Feeders | Variable |
| Crushers | Variable |
| Deaerators | |
| Heaters | |
| Boiler feed pumps | |
| Condensate system | |
| Water treating system | |
| Chemical feed | |
| Coal handling system | Variable |
| Ash disposal system | Variable |
| Thawing equipment | |
| Fuel-oil system | |

N.A. - Not applicable.
(continued)

TABLE 34. (continued)

| INSTALLATION COSTS, DIRECT (cont.) | |
|--|-----------------|
| Foundations and supports | <u>Variable</u> |
| Ductwork (not incl. w/boiler) | <u>Variable</u> |
| Piping | <u>Variable</u> |
| Insulation | <u>Variable</u> |
| Painting | <u>Variable</u> |
| Electrical | |
| Buildings | <u>Variable</u> |
| Total installation cost | _____ |
| TOTAL DIRECT COSTS (equipment + installation) | _____ |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | _____ |
| Construction and field expense (10% of direct costs) | _____ |
| Construction fees (10% of direct costs) | _____ |
| Start-up (2% of direct costs) | _____ |
| Performance tests (minimum \$2000) | _____ |
| TOTAL INDIRECT COSTS | _____ |
| Contingencies (20% of direct and indirect costs) | <u>N/A</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>N/A</u> |
| Land | <u>N/A</u> |
| Working capital (25% of total direct operating costs) | <u>N/A</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u>N/A</u> |

N/A - Not applicable.

TABLE 35. FORMAT FOR PRESENTATION OF ANNUALIZED COSTS
OF INDUSTRIAL BOILERS

DIRECT COST

| | |
|-----------------------|-----------------------------|
| Direct labor | <u>Non-variable</u> |
| Supervision | <u>Non-variable</u> |
| Maintenance labor | <u>Non-variable</u> |
| Maintenance materials | <u>Non-variable</u> |
| Replacement parts | <u>Non-variable</u> |
| Electricity | <u>Variable</u> |
| Steam | <u>Variable</u> |
| Cooling water | <u>Variable</u> |
| Process water | <u>Variable</u> |
| Fuel | <u>Variable^a</u> |
| Bottom ash disposal | <u>Variable</u> |
| Chemicals | <u>Variable</u> |
| Total direct cost | <u>Variable</u> |

OVERHEAD

| | |
|--------------------------------------|---------------------|
| Payroll (30% of direct labor | <u>Non-variable</u> |
| Plant (26% of labor, parts & maint.) | <u>Non-variable</u> |
| Total overhead costs | <u>Non-variable</u> |

BY-PRODUCT CREDITS

N/A

CAPITAL CHARGES

| | |
|---|------------|
| G & A, taxes & insurance (4% of total turnkey costs) | <u>N/A</u> |
| Capital recovery factor (% of total turnkey costs) | <u>N/A</u> |
| Interest on working capital (10% of working capital) | <u>N/A</u> |
| Total capital charges | <u>N/A</u> |

TOTAL ANNUALIZED COSTS

N/A

^a Not included in the equations.

N.A. - Not applicable.

capacities (i.e. 5, 15, and 29×10^6 Btu/h). This step was followed for all major boiler-fuel types including plots for residual oil-fired fire-tube, distillate oil-fired fire-tube, natural gas-fired fire-tube, stoker coal-fired package water-tube, residual oil/natural gas-fired package water-tube, distillate oil/natural gas-fired package water-tube, stoker coal-fired field-erected water-tube, pulverized coal-fired field-erected water-tube, residual oil/natural gas-fired field-erected water-tube, and distillate oil/natural gas-fired field-erected water-tube.

Determination of Cost Equation Form

Each plot is then examined to determine the approximate form of the cost equation. If the plot is a straight line, the equation is a simple binomial of the form $y = ax + b$ where a and b are constants. If the plot is curved, the points are replotted on log-log scales and on semi-log scales. If the plot on log-log scales is a straight line, the equation is of the form $y = ax^b$, where a and b are constants. If the plot on semi-log scales is a straight line, the equation will be of the form $y = ab^{cx}$, where a , b , and c are constants.

Derivation of Cost Equation

Depending upon which equation exhibits the best fit, a regression analysis is performed via a computer program which will determine the values of the constants for each equation form.

Boiler Cost Equation Results

The cost equations for the package water-tube underfeed stoker boilers are presented in Table 36. Equations for field-erected water-tube spreader stoker boilers are presented in Table 37. Table

TABLE 36. COST EQUATIONS FOR PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILERS^{a,b,c,d,e,f,g}

Equipment cost

$$y = 66,392x^{0.622} (11,800/z) + 2257x^{0.819}$$

Direct installation cost

$$y = 53,219x^{0.65} (11,800/z) + 2882x^{0.796}$$

Indirect installation cost

$$y = 40,188x^{0.646} (11,800/z)^{0.926}$$

Variable annual operating cost^h

$$y = [6012x^{0.689} (11,800/z)^{0.9} (A/10.6)^{0.3}] (H/5256)$$

Nonvariable annual costⁱ

$$y = [308,900 + 7176x] (11,800/z)^{0.166}$$

^a x = heat input rate (10⁶ Btu/h)

^b y = actual cost (\$)

^c z = heating value of coal (Btu/lb)

^d A = ash content of coal (%)

^e H = equivalent hours operated per year at maximum capacity.

^f Costs are in June 1978 dollars.

^g Applicable to heat inputs ranging from 15 to 60 x 10⁶ Btu/h.

^h Does not include fuel cost.

ⁱ Excludes capital charges.

TABLE 37. COST EQUATIONS FOR FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILERS^{a,b,c,d,e,f,g}

| |
|--|
| Equipment cost (size $\leq 150 \times 10^6$ Btu/h) |
| $y = 25,052x^{0.906} (11,800/z) + 4,626x^{0.868}$ |
| Equipment cost (size $> 150 \times 10^6$ Btu/h) |
| $y = 25,052x^{0.906} (11,800/z) + 14,205x^{0.714}$ |
| Direct installation cost (size $\leq 150 \times 10^6$ Btu/h) |
| $y = 45,468x^{0.757} (11,800/z) + 2,919x^{0.869}$ |
| Direct installation cost (size $> 150 \times 10^6$ Btu/h) |
| $y = 45,468x^{0.757} (11,800/z) + 9464x^{0.647}$ |
| Indirect installation cost |
| $y = 21,154x^{0.867} (11,800/z)^{0.86}$ |
| Variable annual operating cost ^h |
| $y = 3,566x^{0.743} (11,800/z) (A/10.6)^{0.3} \left(\frac{H}{5256}\right)$ |
| Nonvariable annual cost ⁱ |
| $y = 66,924x^{0.574} (11,800/z)^{0.188}$ |

^a x = heat input rate (10^6 Btu/h)

^b y = actual cost (\$)

^c z = heating value of coal (Btu/lb)

^d A = ash content of coal (%)

^e H = equivalent hours operated per year at maximum capacity.

^f Costs are in June 1978 dollars.

^g Applicable to heat inputs ranging from 75 to 200×10^6 Btu/h.

^h Does not include fuel cost.

ⁱ Excludes capital charges.

38 presents cost equations for field-erected, water-tube, pulverized-coal-fired boilers. The cost equations for package fire-tube boilers are presented in Table 39. In Table 40 are presented cost equations for dual-fuel water-tube boilers firing residual oil/natural gas. The cost equations for dual-fuel water-tube boilers firing distillate oil/natural gas are presented in Table 41.

The algorithms are varied in form from boiler to boiler and from fuel to fuel. The equations are an approximation of the way the actual costs of boilers vary with size, fuel, and type. The equations are composites of the costs of many components that do not vary in the same manner between sizes, boiler types, and fuels. However, comparisons of costs derived from the equations to detailed costs presented in the appendices, show that the equations give costs at least within 8 percent of the detailed cost estimates.

Plots of Various Detailed Cost Items Versus Heat Input Design Capacity

Plots of different detailed cost items versus heat input have been included. The primary advantage of the plots is that cost trends are more readily observed than by examination of the algorithms or detailed cost estimates. They are also useful in comparing costs of different boiler types.

Figures 1, 2, and 3 provide the equipment costs of boilers with fans and ducts versus heat input. Plots of total turnkey costs versus heat input are shown in Figures 4 through 8. Figures 9 through 11 show operating and maintenance costs (direct cost plus overhead less fuel cost) versus equivalent hours of operation per year at maximum capacity for selected boilers.

TABLE 38. COST EQUATIONS FOR FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILERS^{a,b,c,d,e,f,g}

Equipment cost

$$y = [904,426 + 14,564x] (11,800/z) + 92,079 + 3,107x$$

Direct installation cost

$$y = 24,019x^{0.886} (11,800/z) + 17,395 + 1,254x$$

Indirect installation cost

$$y = 22,782x^{0.877} (11,800/z)^{0.87}$$

Variable annual operating cost^h

$$y = 1,586x^{1.006} (11,800/z)^{0.9} (A/10.6)^{0.13} \left(\frac{H}{5256}\right)$$

Nonvariable annual costⁱ

$$y = 60,380x^{0.604} \left(\frac{11,800}{z}\right)^{0.26}$$

^a x = heat input rate (10⁶ Btu/h)

^b y = actual cost (\$)

^c z = heating value of coal (Btu/lb)

^d A = ash content of coal (%)

^e H = equivalent hours operated per year at maximum capacity.

^f Costs are in June 1978 dollars.

^g Applicable to heat inputs ranging from 200 to 700 x 10⁶ Btu/h.

^h Does not include fuel cost.

ⁱ Excludes capital charges.

TABLE 39. COST EQUATIONS FOR PACKAGE
FIRE-TUBE BOILERS^{a,b,c,d,e}

| Residual Oil-Fired | |
|---|------------------------------|
| Equipment cost | $y = 17,360x^{0.557}$ |
| Direct installation cost | $y = 4324x + 56,177$ |
| Indirect installation cost | $y = 2317x + 29,749$ |
| Variable annual operating cost ^f (heat input $\leq 15 \times 10^6$ Btu/h) | $y = [580x + 3900] (H/3942)$ |
| Variable annual operating cost ^f (heat input $>15 \times 10^6$ Btu/h) | $y = [914x - 1114] (H/3942)$ |
| Nonvariable annual cost ^g (heat input $\leq 15 \times 10^6$ Btu/h) | $y = 11,530x + 136,850$ |
| Nonvariable annual cost ^g (heat input $>15 \times 10^6$ Btu/h) | $y = 900x + 296,300$ |
| Natural Gas-Fired or Distillate Oil-Fired | |
| Equipment cost | $y = 15,981x^{0.561}$ |
| Direct installation cost | $y = 4261x + 56,041$ |
| Indirect installation cost | $y = 2256x + 28,649$ |
| Variable annual operating cost ^f (heat input $\leq 15 \times 10^6$ Btu/h) | $y = [580x + 3900] (H/3942)$ |
| Variable annual operating cost ^f (heat input $>15 \times 10^6$ Btu/h) | $y = [914x - 1114] (H/3942)$ |
| Nonvariable annual cost ^g (heat input $\leq 15 \times 10^6$ Btu/h) | $y = 11,530x + 136,850$ |
| Nonvariable annual cost ^g (heat input $>15 \times 10^6$ Btu/h) | $y = 900x + 296,300$ |

^a x = heat input rate (10^6 Btu/h).

^b y = actual cost (\$).

^c H = equivalent hours operated
per year at maximum capacity.

^d Costs in June 1978 dollars.

^e Applicable to heat inputs
ranging from 1 to 30×10^6 Btu/h.

^f Does not include fuel cost.

^g Excludes capital charges.

TABLE 40. COST EQUATIONS FOR WATER-TUBE, DUAL-FUEL
BOILERS FIRING RESIDUAL OIL/NATURAL GAS^{a,b,c,d}

| Package Units ^e | |
|---|--------------------------------|
| Equipment cost | $y = 15,925x^{0.775}$ |
| Direct installation cost | $y = 54,833x^{0.364}$ |
| Indirect installation cost | $y = 16,561x^{0.613}$ |
| Variable annual operating cost ^f | $y = [202x + 24,262] (H/4818)$ |
| Nonvariable annual cost ^g | $y = 2048x + 266,078$ |

| Field-Erected Units ^h | |
|---|--------------------------------|
| Equipment cost | $y = 8602x + 714,824$ |
| Direct installation cost | $y = 18,427x^{0.866}$ |
| Indirect installation cost | $y = 16,306x^{0.835}$ |
| Variable annual operating cost ^f | $y = [269x + 25,884] (H/4818)$ |
| Nonvariable annual cost ^g | $y = 31,628x^{0.61}$ |

^a x = heat input rate (10^6 Btu/h).

^b y = actual cost (\$).

^c H = equivalent hours operated per year at maximum capacity.

^d Costs in June 1978 dollars.

^e Applicable to heat inputs ranging from 30 to 150×10^6 Btu/h.

^f Does not include fuel cost.

^g Excludes capital charges.

^h Applicable to heat input ranging from 200 to 700×10^6 Btu/h.

TABLE 41. COST EQUATIONS FOR WATER-TUBE, DUAL-FUEL
BOILERS FIRING DISTILLATE OIL/NATURAL GAS^{a,b,c,d}

| Package Units ^e | |
|---|--------------------------------|
| Equipment cost | $y = 14,850x^{0.786}$ |
| Direct installation cost | $y = 54,620x^{0.361}$ |
| Indirect installation cost | $y = 15,952x^{0.618}$ |
| Variable annual operating cost ^f | $y = [202x + 24,262] (H/4818)$ |
| Nonvariable annual cost ^g | $y = 2048x + 266,078$ |
| Field-Erected Units ^h | |
| Equipment cost | $y = 8372x + 711,271$ |
| Direct installation cost | $y = 18,262x^{0.865}$ |
| Indirect installation cost | $y = 4812x + 431,779$ |
| Variable annual operating cost ^f | $y = [269x + 25,884] (H/4818)$ |
| Nonvariable annual cost ^g | $y = 31,628x^{0.61}$ |

^a x = heat input rate (10^6 Btu/h).

^b y = actual cost (\$).

^c H = equivalent hours operated per year at maximum capacity.

^d Costs in June 1978 dollars.

^e Applicable to heat inputs ranging from 30 to 150×10^6 Btu/h.

^f Does not include fuel cost.

^g Excludes capital charges.

^h Applicable to heat input ranging from 200 to 700×10^6 Btu/h.

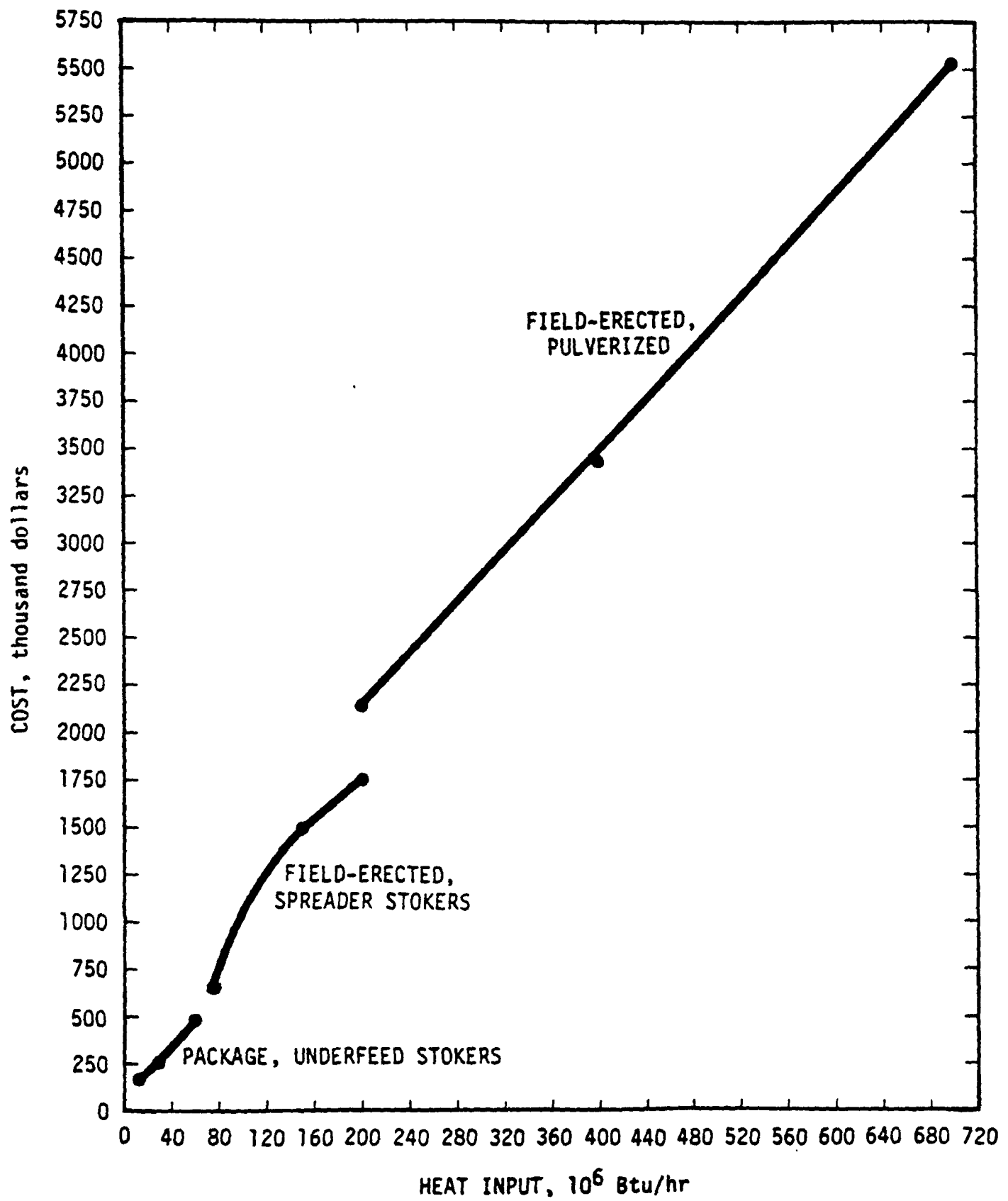


Figure 1. Equipment costs of water-tube boilers (with fans and ducts) firing eastern low-sulfur coal versus heat input.

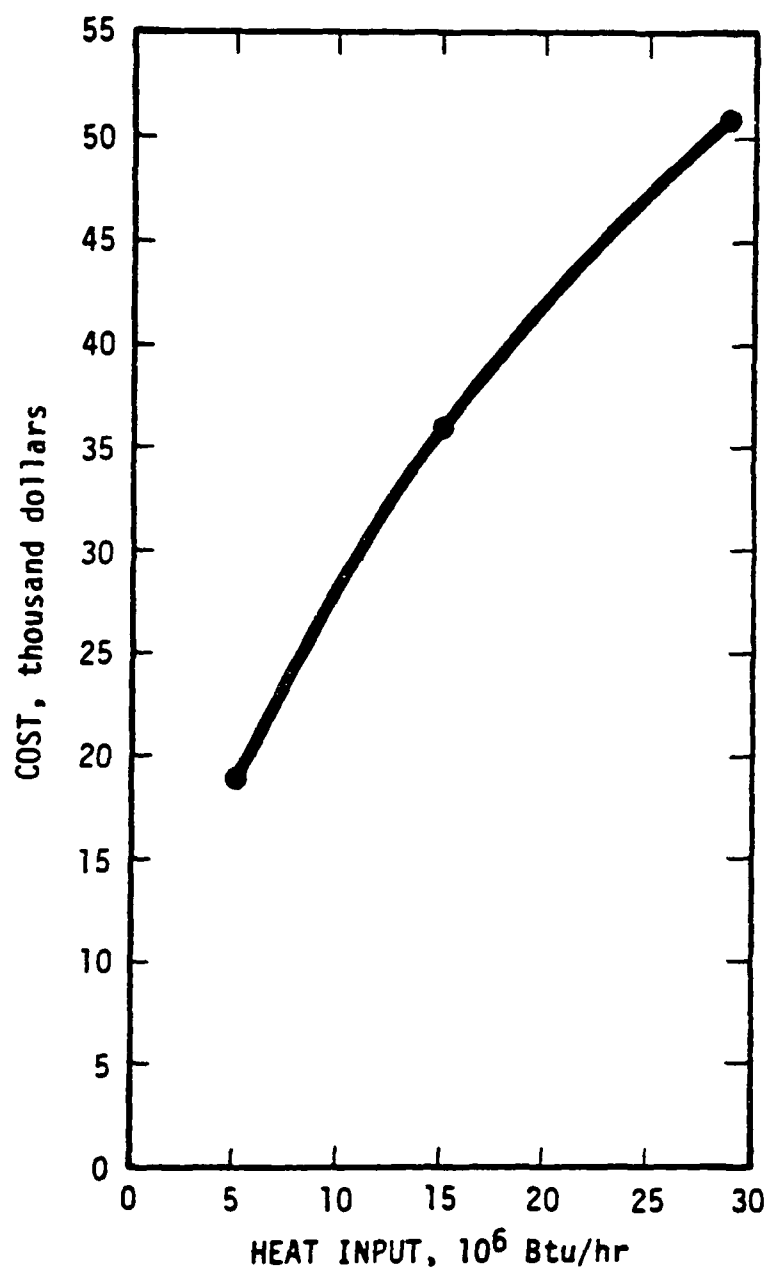


Figure 2. Equipment costs of package, fire-tube boilers (with fans and ducts) firing residual oil, distillate oil or natural gas versus heat input.

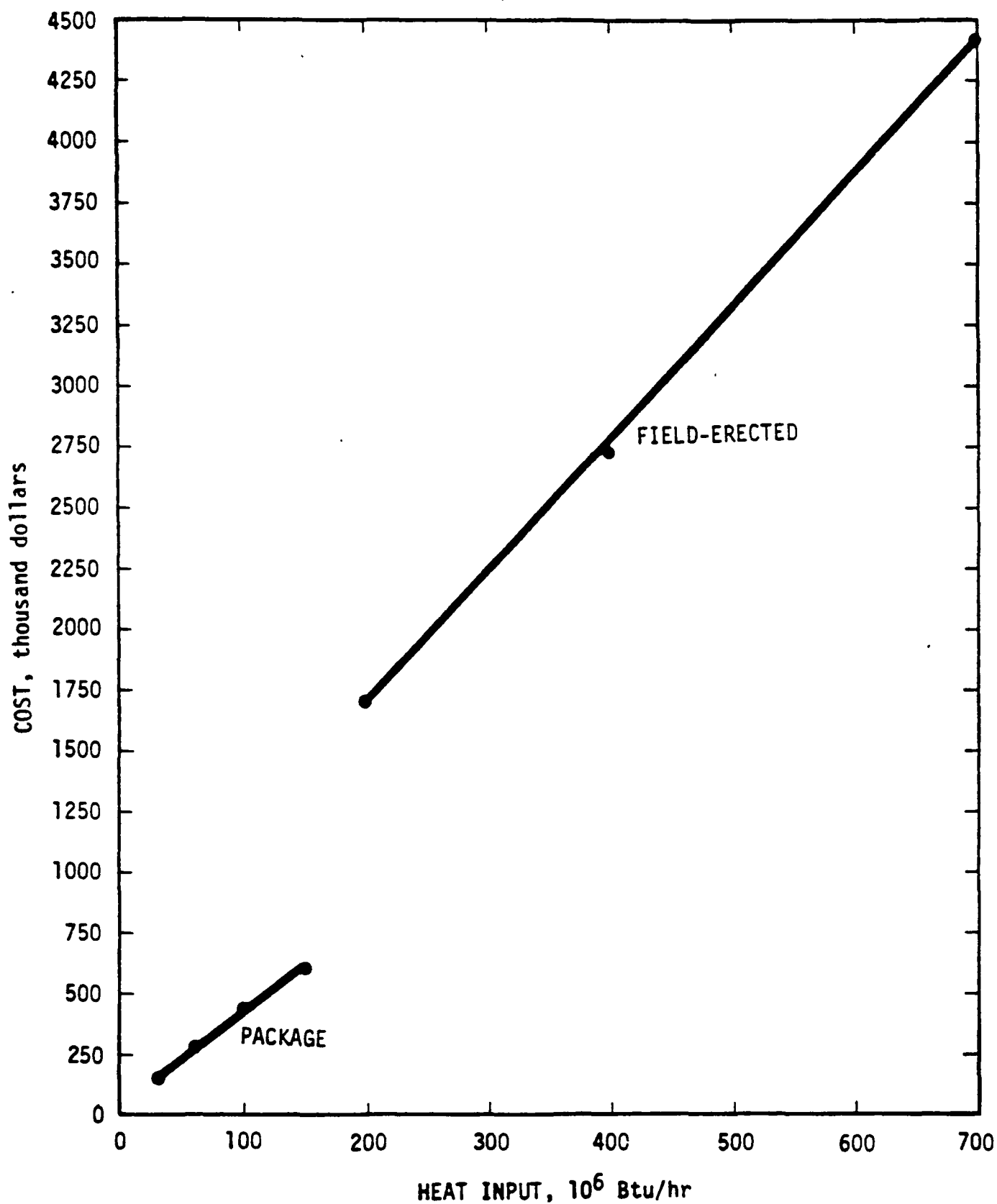


Figure 3. Equipment costs of dual-fuel, water-tube boilers (with fans and ducts) firing residual oil/natural gas or distillate oil/natural gas versus heat input.

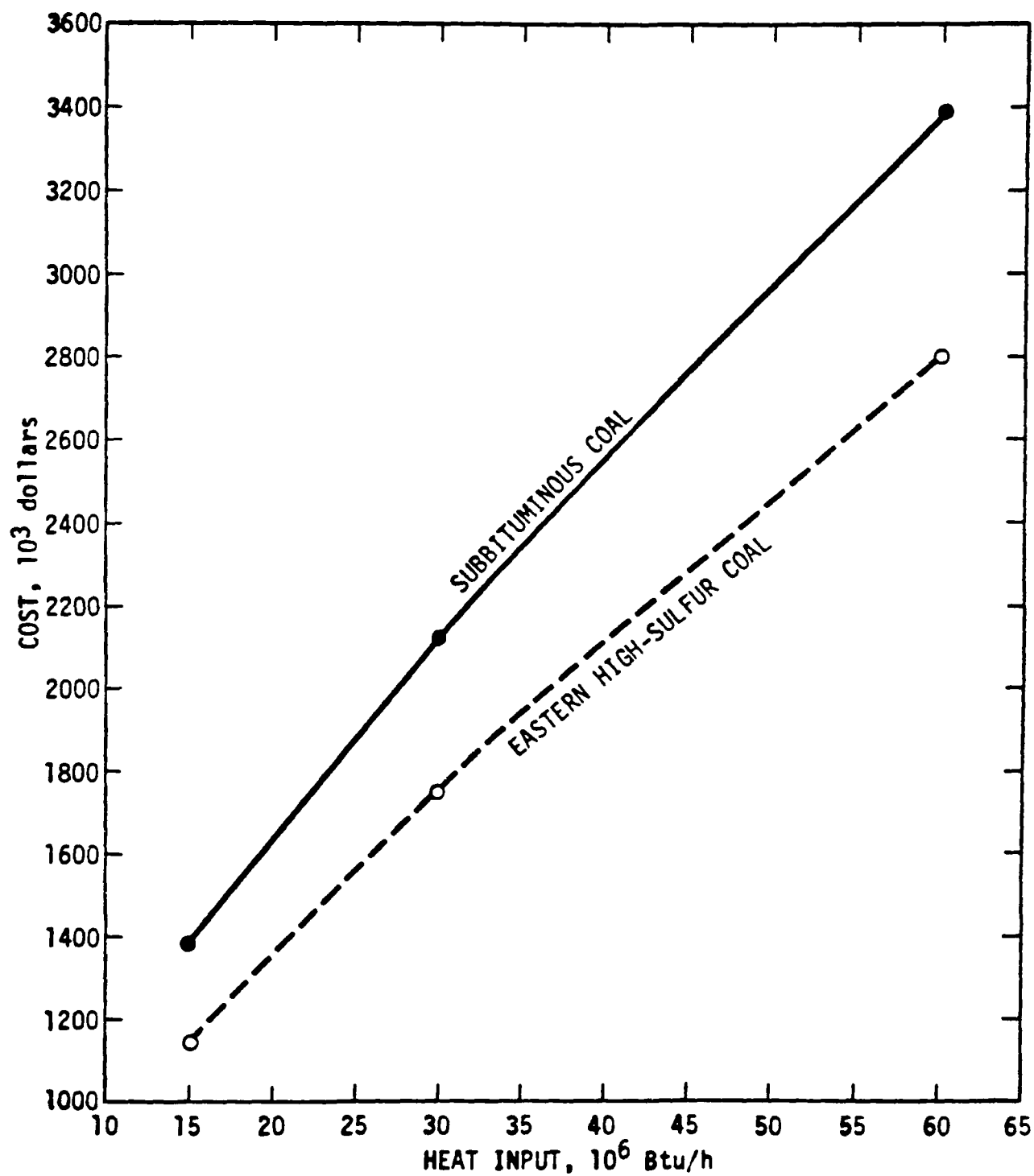


Figure 4. Total turnkey costs of coal-fired, package, underfeed-stoker boilers firing eastern high-sulfur coal or subbituminous coal versus heat input.

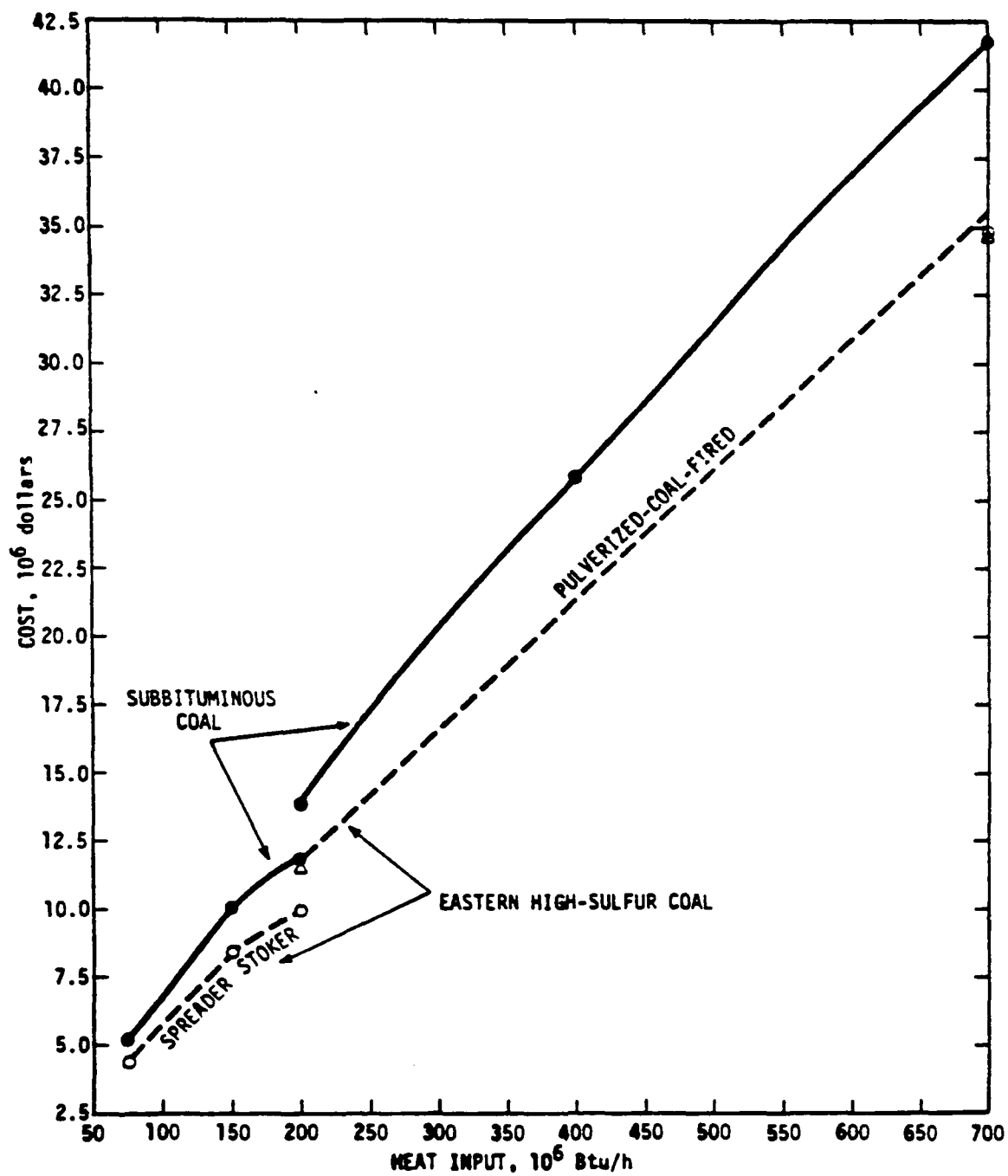


Figure 5. Total turnkey costs of coal-fired, field-erected boilers firing eastern high sulfur coal or subbituminous coal versus heat input.

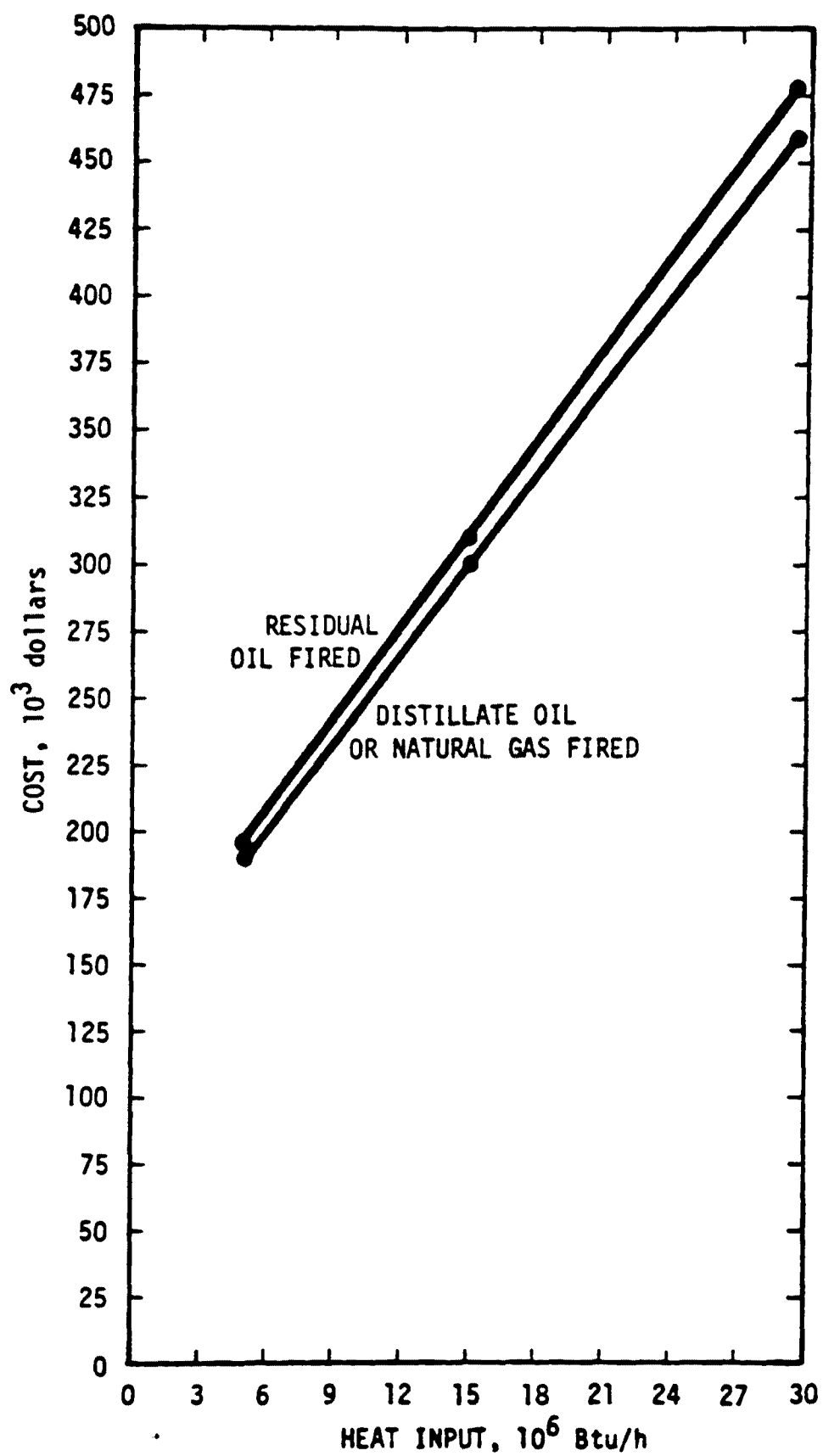


Figure 6. Total turnkey costs of package, fire-tube boilers firing residual oil, distillate oil, or natural gas versus heat input.

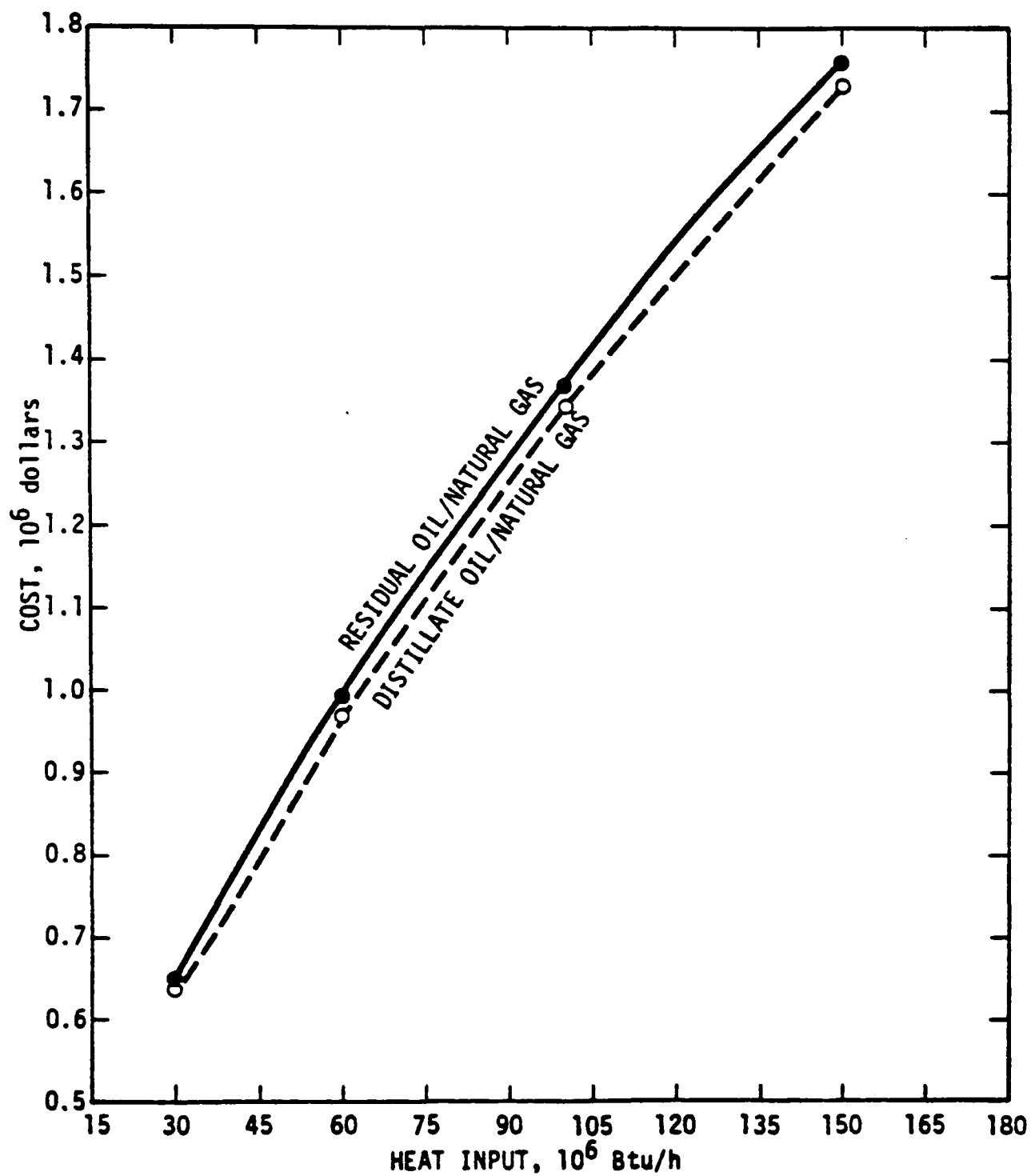


Figure 7. Total turnkey costs of dual-fuel, package boilers firing residual oil/natural gas or distillate oil/natural gas versus heat input.

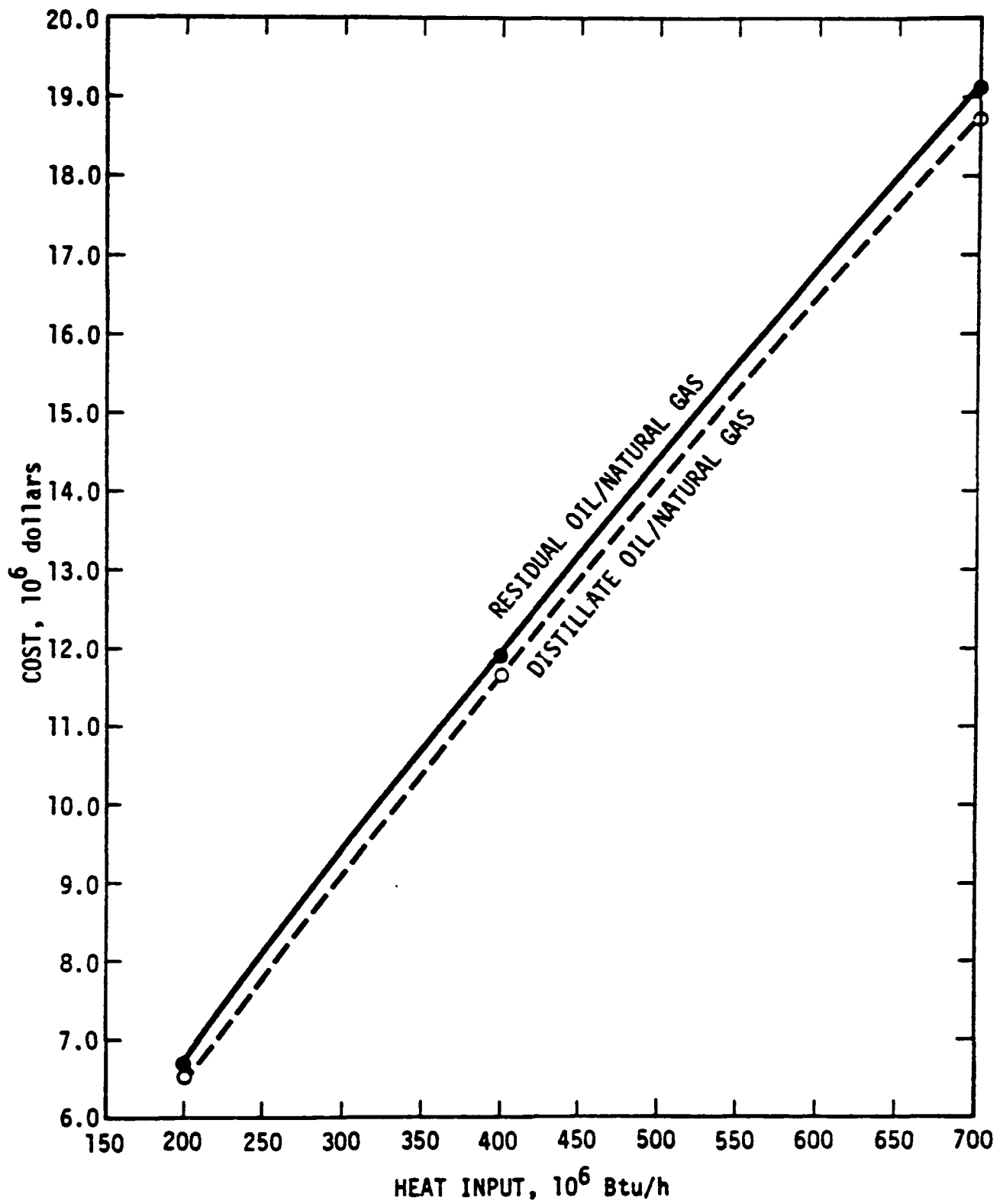


Figure 8. Total turnkey costs of dual-fuel, field-erected boilers firing residual oil/natural gas or distillate oil/natural gas versus heat input.

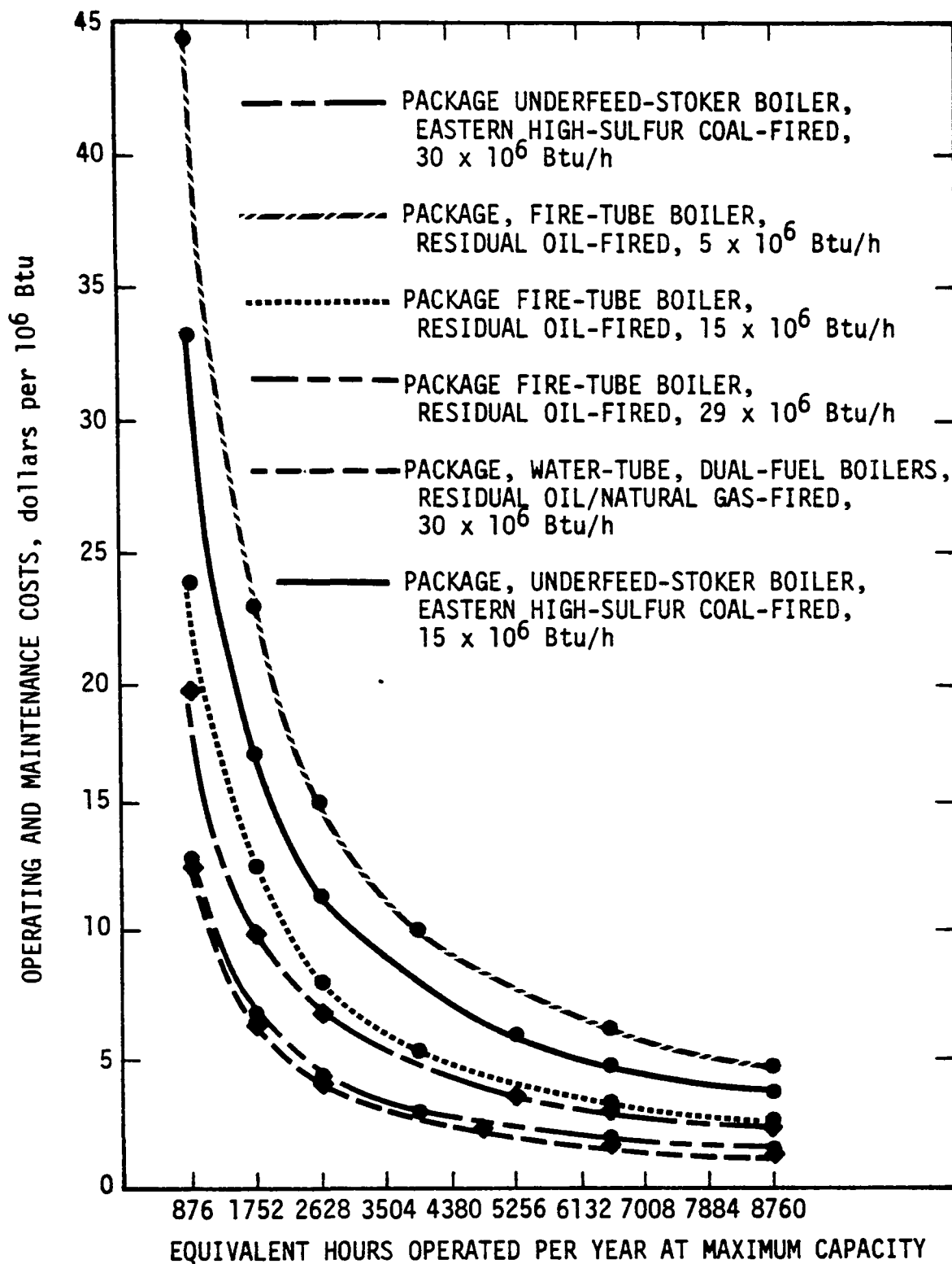


Figure 9. Operating and maintenance costs (less fuel costs) for various boilers versus equivalent hours operated per year at maximum capacity.

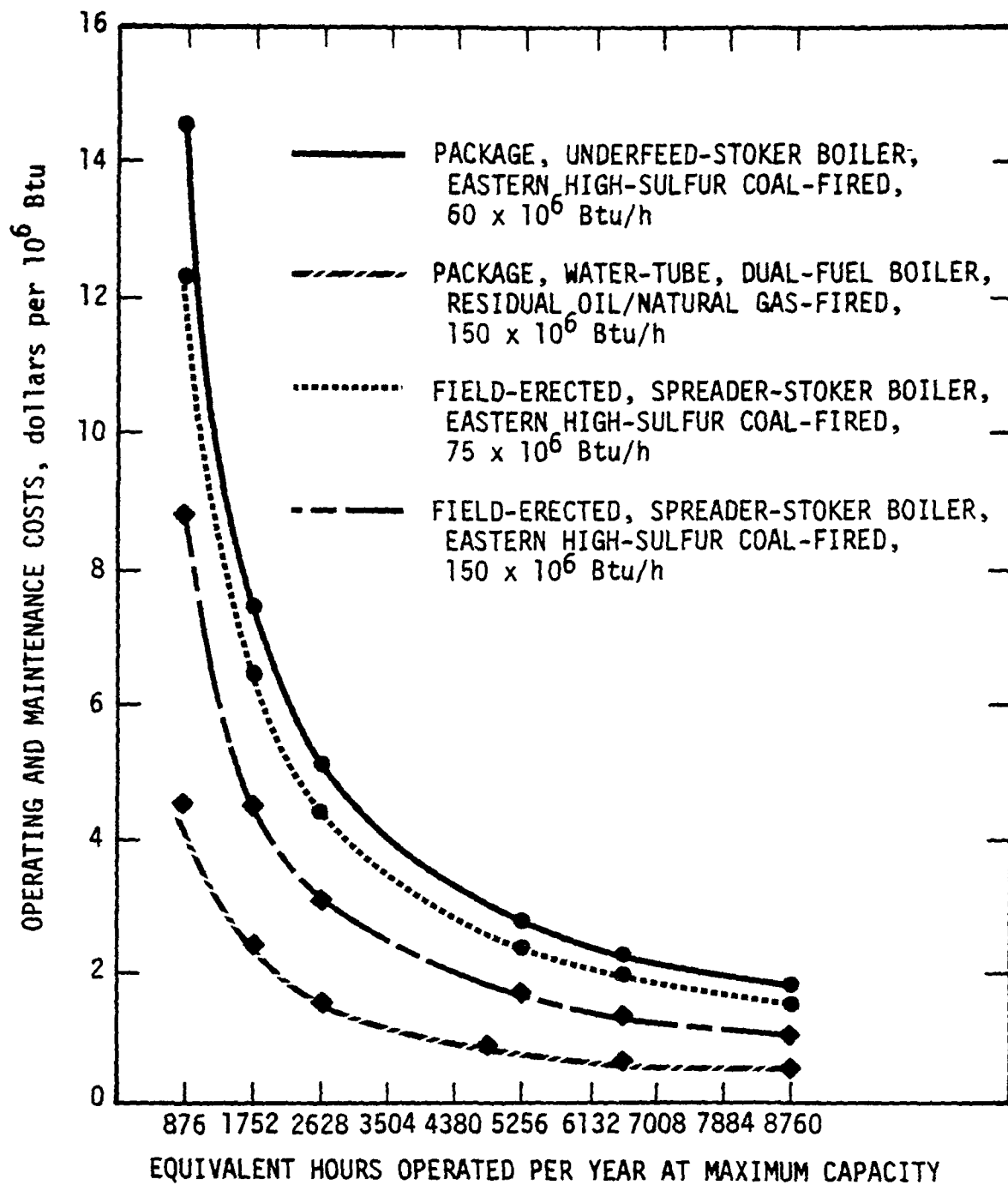


Figure 10. Operating and maintenance costs (less fuel costs) for various boilers versus equivalent hours operated per year at maximum capacity.

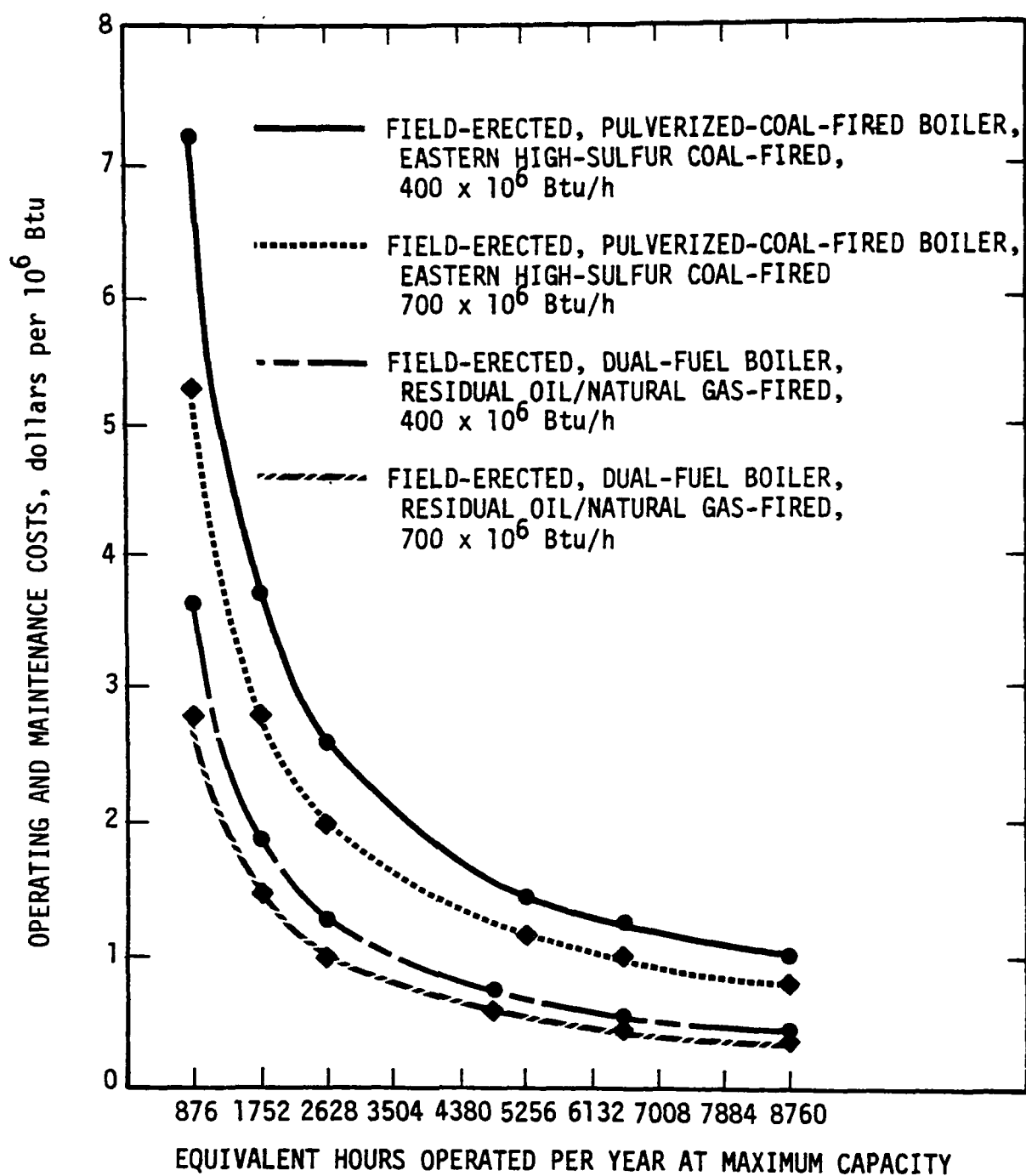


Figure 11. Operating and maintenance costs (less fuel costs) for various boilers versus equivalent hours operated per year at maximum capacity.

APPENDIX A

DETAILED CAPITAL AND ANNUALIZED COST
TABLES FOR COAL-FIRED BOILERS

TABLE A-1. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 204,800 |
| Stack | 2,700 |
| Instrumentation | Incl. w/boiler |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | Incl. w/coal handling |
| Heaters | N.A. |
| Boiler feed pumps | 6,100 |
| Condensate systems | 5,000 |
| Water treating system | 5,000 |
| Chemical feed | 1,400 |
| Compressed air system | N.A. |
| Coal handling system | 90,100 |
| Ash disposal system | 65,500 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$380,600 |

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 69,000 |
| Stack | 1,500 |
| Instrumentation | Incl. w/boiler |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | N.A. |
| Heaters | N.A. |
| Boiler feed pumps | 1,200 |
| Condensate system | 1,000 |
| Water treating system | 1,500 |
| Chemical feed | 400 |
| Coal handling system | 53,800 |
| Ash disposal system | 26,900 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-1. (continued)

| | |
|---|-------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | 23,400 |
| Ductwork (not incl. w/boiler) | N.A. |
| Piping | 23,400 |
| Insulation | 17,600 |
| Painting | 4,100 |
| Electrical | 20,000 |
| Buildings | 93,600 |
| Total installation cost | \$ 337,400 |
| TOTAL DIRECT COSTS (equipment + installation) | \$ 718,000 |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ 71,800 |
| Construction and field expense (10% of direct costs) | 71,800 |
| Construction fees (10% of direct costs) | 71,800 |
| Start-up (2% of direct costs) | 14,400 |
| Performance tests (minimum \$2000) | 3,000 |
| TOTAL INDIRECT COSTS | \$ 232,800 |
| Contingencies (20% of direct and indirect costs) | \$ 190,200 |
| Total Turnkey Costs (direct+indirect+contingencies) | 1,141,000 |
| Land | 2,000 |
| Working capital (25% of total direct operating costs) | 102,000 |
| GRAND TOTAL (turnkey+land+working capital) | \$1,245,000 |

N.A. - Not applicable

^a Quote from Zurn Industries, Inc., May 25, 1978.

TABLE A-2. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|-------------------|
| Direct labor | <u>\$ 131,600</u> |
| Supervision | <u>68,500</u> |
| Maintenance labor | <u>64,100</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>46,800</u> |
| Electricity | <u>25,800</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>200</u> |
| Fuel | <u>58,300</u> |
| Bottom ash disposal | <u>10,500</u> |
| Chemicals | <u>2,000</u> |
| Total direct cost | <u>\$ 407,800</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | <u>\$ 39,500</u> |
| Plant (26% of labor, parts & maint.) | <u>80,900</u> |
| Total overhead costs | <u>\$ 120,400</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|-------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | <u>\$ 45,600</u> |
| Capital recovery factor (10.61% of total turnkey costs) | <u>121,100</u> |
| Interest on working capital (10% of working capital) | <u>10,200</u> |
| Total capital charges | <u>\$ 176,900</u> |

| | |
|------------------------|-------------------|
| TOTAL ANNUALIZED COSTS | <u>\$ 705,100</u> |
|------------------------|-------------------|

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-3. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 175,000 |
| Stack | 2,700 |
| Instrumentation | Incl. w/boiler |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | Incl. w/condensate |
| Heaters | N.A. |
| Boiler feed pumps | 6,100 |
| Condensate systems | 5,000 |
| Water treating system | 5,000 |
| Chemical feed | 1,400 |
| Compressed air system | N.A. |
| Coal handling system | 77,000 |
| Ash disposal system | 56,000 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 328,200 |

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 59,000 |
| Stack | 1,500 |
| Instrumentation | Incl. w/boiler |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | N.A. |
| Heaters | N.A. |
| Boiler feed pumps | 1,200 |
| Condensate system | 1,000 |
| Water treating system | 1,500 |
| Chemical feed | 400 |
| Coal handling system | 46,000 |
| Ash disposal system | 23,000 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-3. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|---------------|
| Foundations and supports | <u>20,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>20,000</u> |
| Insulation | <u>15,000</u> |
| Painting | <u>3,500</u> |
| Electrical | <u>20,000</u> |
| Buildings | <u>80,000</u> |

| | |
|-------------------------|-------------------|
| Total installation cost | <u>\$ 292,100</u> |
|-------------------------|-------------------|

| | |
|--|-------------------|
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 620,300</u> |
|--|-------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|------------------|
| Engineering (10% of direct costs) | <u>\$ 62,000</u> |
| Construction and field expense (10% of direct costs) | <u>62,000</u> |
| Construction fees (10% of direct costs) | <u>62,000</u> |
| Start-up (2% of direct costs) | <u>12,400</u> |
| Performance tests (minimum \$2000) | <u>3,000</u> |

| | |
|----------------------|-------------------|
| TOTAL INDIRECT COSTS | <u>\$ 201,400</u> |
|----------------------|-------------------|

| | |
|---|-------------------|
| Contingencies (20% of direct and indirect costs) | <u>\$ 164,300</u> |
|---|-------------------|

| | |
|--|----------------|
| Total Turnkey Costs (direct+indirect+contingencies) | <u>986,000</u> |
|--|----------------|

| | |
|------|--------------|
| Land | <u>2,000</u> |
|------|--------------|

| | |
|--|----------------|
| Working capital (25% of total direct operating costs) | <u>106,600</u> |
|--|----------------|

| | |
|---|--------------------|
| GRAND TOTAL (turnkey+land+working capital) | <u>\$1,094,600</u> |
|---|--------------------|

N.A. - Not applicable.

^aQuote from Zurn Industries, Inc., May 25, 1978.

TABLE A-4. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|-------------------|
| Direct labor | <u>\$ 131,600</u> |
| Supervision | <u>68,500</u> |
| Maintenance labor | <u>64,100</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>40,000</u> |
| Electricity | <u>22,000</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>200</u> |
| Fuel | <u>91,500</u> |
| Bottom ash disposal | <u>6,300</u> |
| Chemicals | <u>2,000</u> |
| Total direct cost | <u>\$ 426,200</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | <u>\$ 39,500</u> |
| Plant (26% of labor, parts & maint.) | <u>79,100</u> |
| Total overhead costs | <u>\$ 118,600</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|-------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | <u>\$ 39,400</u> |
| Capital recovery factor (10.61 % of total turnkey costs) | <u>104,600</u> |
| Interest on working capital (10% of working capital) | <u>10,700</u> |
| Total capital charges | <u>\$ 154,700</u> |

| | |
|------------------------|-------------------|
| TOTAL ANNUALIZED COSTS | <u>\$ 699,500</u> |
|------------------------|-------------------|

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-5. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 252,000 |
| Stack | 2,700 |
| Instrumentation | Incl. w/boiler |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | Incl. w/condensate |
| Heaters | N.A. |
| Boiler feed pumps | 6,100 |
| Condensate systems | 5,000 |
| Water treating system | 5,000 |
| Chemical feed | 1,400 |
| Compressed air system | N.A. |
| Coal handling system | 110,900 |
| Ash disposal system | 80,600 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 463,700 |

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 85,000 |
| Stack | 1,500 |
| Instrumentation | Incl. w/boiler |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | N.A. |
| Heaters | N.A. |
| Boiler feed pumps | 1,200 |
| Condensate system | 1,000 |
| Water treating system | 1,500 |
| Chemical feed | 400 |
| Coal handling system | 66,200 |
| Ash disposal system | 33,100 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-5. (continued)

| | |
|---|---------------------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | <u>28,800</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>28,800</u> |
| Insulation | <u>21,600</u> |
| Painting | <u>5,000</u> |
| Electrical | <u>20,000</u> |
| Buildings | <u>115,200</u> |
| Total installation cost | <u>\$ 409,300</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 873,000</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 87,300</u> |
| Construction and field expense (10% of direct costs) | <u>87,300</u> |
| Construction fees (10% of direct costs) | <u>87,300</u> |
| Start-up (2% of direct costs) | <u>17,500</u> |
| Performance tests (minimum \$2000) | <u>3,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 282,400</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 231,100</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>1,386,500</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>98,800</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u><u>\$1,487,300</u></u> |

N.A. - Not applicable

^aQuote from Zurn Industries, Inc., May 25, 1978.

TABLE A-6. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

| | |
|---|-------------------|
| DIRECT COST | |
| Direct labor | \$ 131,600 |
| Supervision | 68,500 |
| Maintenance labor | 64,100 |
| Maintenance materials | a |
| Replacement parts | 57,600 |
| Electricity | 31,600 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 200 |
| Fuel | 33,100 |
| Bottom ash disposal | 6,300 |
| Chemicals | 2,000 |
| Total direct cost | \$ 395,000 |
| OVERHEAD | |
| Payroll (30% of direct labor | \$ 39,500 |
| Plant (26% of labor, parts & maint.) | 83,700 |
| Total overhead costs | \$ 123,200 |
| BY-PRODUCT CREDITS | N.A. |
| CAPITAL CHARGES | |
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 55,500 |
| Capital recovery factor (10.61 % of total turnkey costs) | 147,100 |
| Interest on working capital (10% of working capital) | 9,900 |
| Total capital charges | \$ 212,500 |
| TOTAL ANNUALIZED COSTS | \$ 730,700 |

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-7. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 182,700 |
| Stack | 2,700 |
| Instrumentation | Incl. w/boiler |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | Incl. w/condensate |
| Heaters | N.A. |
| Boiler feed pumps | 6,100 |
| Condensate systems | 5,000 |
| Water treating system | 5,000 |
| Chemical feed | 1,400 |
| Compressed air system | N.A. |
| Coal handling system | 80,400 |
| Ash disposal system | 58,500 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 341,800 |

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 61,600 |
| Stack | 1,500 |
| Instrumentation | Incl. w/boiler |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | N.A. |
| Heaters | N.A. |
| Boiler feed pumps | 1,200 |
| Condensate system | 1,000 |
| Water treating system | 1,500 |
| Chemical feed | 400 |
| Coal handling system | 48,000 |
| Ash disposal system | 24,000 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-7. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|---------------|
| Foundations and supports | <u>20,900</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>20,900</u> |
| Insulation | <u>15,700</u> |
| Painting | <u>3,700</u> |
| Electrical | <u>20,000</u> |
| Buildings | <u>83,500</u> |

| | |
|-------------------------|-------------------|
| Total installation cost | <u>\$ 303,900</u> |
|-------------------------|-------------------|

TOTAL DIRECT COSTS

| | |
|----------------------------|-------------------|
| (equipment + installation) | <u>\$ 645,700</u> |
|----------------------------|-------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|------------------|
| Engineering (10% of direct costs) | <u>\$ 64,600</u> |
| Construction and field expense (10% of direct costs) | <u>64,600</u> |
| Construction fees (10% of direct costs) | <u>64,600</u> |
| Start-up (2% of direct costs) | <u>12,900</u> |
| Performance tests (minimum \$2000) | <u>3,000</u> |

| | |
|----------------------|-------------------|
| TOTAL INDIRECT COSTS | <u>\$ 209,700</u> |
|----------------------|-------------------|

Contingencies

| | |
|------------------------------------|-------------------|
| (20% of direct and indirect costs) | <u>\$ 171,100</u> |
|------------------------------------|-------------------|

Total Turnkey Costs

| | |
|---------------------------------|------------------|
| (direct+indirect+contingencies) | <u>1,026,500</u> |
|---------------------------------|------------------|

| | |
|------|--------------|
| Land | <u>2,000</u> |
|------|--------------|

| | |
|--|----------------|
| Working capital (25% of total direct operating costs) | <u>104,700</u> |
|--|----------------|

GRAND TOTAL

| | |
|--------------------------------|--------------------|
| (turnkey+land+working capital) | <u>\$1,133,200</u> |
|--------------------------------|--------------------|

^aQuote from Zurn Industries, Inc., May 25, 1978
N.A. - Not applicable.

TABLE A-8. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|-------------------|
| Direct labor | \$ <u>131,600</u> |
| Supervision | <u>68,500</u> |
| Maintenance labor | <u>64,100</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>41,800</u> |
| Electricity | <u>22,900</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>200</u> |
| Fuel | <u>74,900</u> |
| Bottom ash disposal | <u>12,600</u> |
| Chemicals | <u>2,000</u> |
| Total direct cost | \$ <u>418,600</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | \$ <u>39,500</u> |
| Plant (26% of labor, parts & maint.) | <u>79,600</u> |
| Total overhead costs | \$ <u>119,100</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|-------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>41,100</u> |
| Capital recovery factor (10.61 % of total turnkey costs) | <u>108,900</u> |
| Interest on working capital (10% of working capital) | <u>10,500</u> |
| Total capital charges | \$ <u>160,500</u> |

TOTAL ANNUALIZED COSTS \$ 698,200

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-9. ESTIMATED CAPITAL COSTS OF A PACKAGE,
WATER-TUBE, UNDERFEED-STOKER BOILER FIRING EASTERN HIGH-SULFUR
COAL, WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|------------------------------|-----------------------|
| Boiler (with fans and ducts) | \$ 308,900 |
| Stack | 3,000 |
| Instrumentation | Incl. w/boiler |
| Stokers | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerator | 5,200 |
| Heaters | N.A. |
| Boiler feed pumps | 13,400 |
| Condensate systems | 7,700 |
| Water treating system | 8,000 |
| Chemical feed | 1,400 |
| Compressed air system | N.A. |
| Coal handling system | 136,700 |
| Ash disposal system | 99,500 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 583,800 |

INSTALLATION COSTS, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 105,300 |
| Stack | 1,500 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerator | 2,500 |
| Heaters | N.A. |
| Boiler feed pumps | 3,000 |
| Condensate system | 1,100 |
| Water treating system | 2,000 |
| Chemical feed | 800 |
| Coal handling system | 81,900 |
| Ash disposal system | 41,000 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE 1A-9. (continued)

| | |
|--|--------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | 35,100 |
| Ductwork (not incl. w/boiler) | N.A. |
| Piping | 41,000 |
| Insulation | 29,300 |
| Painting | 5,900 |
| Electrical | 30,000 |
| Buildings | 140,400 |
| Total Installation Costs | \$ 520,800 |
| TOTAL DIRECT COSTS (Equipment + Installation) | \$ 1,104,600 |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ 110,500 |
| Construction and field expense (10% of direct costs) | 110,500 |
| Construction fees (10% of direct costs) | 110,500 |
| Startup (2% of direct costs) | 22,100 |
| Performance tests (minimum \$2000) | 3,500 |
| TOTAL INDIRECT COSTS | \$ 357,100 |
| Contingencies (20% of direct and indirect costs) | \$ 292,300 |
| Total turnkey costs (Direct + Indirect + Contingencies) | 1,754,000 |
| Land | 2,000 |
| Working capital (25% of total direct operating costs) | 135,300 |
| GRAND TOTAL (Turnkey + Land + Working Capital) | \$ 1,891,300 |

^a Quote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-10. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE
UNDERFEED-STOKER BOILER FIRING EASTERN HIGH-SULFUR
COAL WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|--------------|
| Direct labor | \$ 157,900 |
| Supervision | 68,500 |
| Maintenance labor | 64,100 |
| Maintenance materials | ^a |
| Replacement parts | 70,200 |
| Electricity | 40,100 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 500 |
| Fuel | 116,700 |
| Bottom ash disposal | 21,000 |
| Chemicals | 2,300 |
| Total direct cost | \$ 541,300 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor) | \$ 47,400 |
| Plant (26% of labor, parts & maint.) | 93,800 |
| Total overhead costs | \$ 141,200 |

BYPRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 70,200 |
| Capital recovery factor (10.61% of total turnkey costs) | 186,100 |
| Interest on working capital (10% of working capital) | 13,500 |
| Total capital charges | \$ 269,800 |

| | |
|------------------------|------------|
| TOTAL ANNUALIZED COSTS | \$ 952,300 |
|------------------------|------------|

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-11. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|-----------------------------|-----------------------|
| Boiler (with fans and duct) | \$ 264,000 |
| Stack | 3,000 |
| Instrumentation | Incl. w/boiler |
| Stokers | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerator | 5,200 |
| Heaters | N.A. |
| Boiler feed pumps | 13,400 |
| Condensate systems | 7,700 |
| Water treating system | 8,000 |
| Chemical feed | 1,400 |
| Compressed air system | N.A. |
| Coal handling system | 116,800 |
| Ash disposal system | 85,000 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |

Total Equipment Cost \$ 504,500

INSTALLATION COSTS, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 90,000 |
| Stack | 1,500 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerator | 2,500 |
| Heaters | N.A. |
| Boiler feed pumps | 3,000 |
| Condensate system | 1,100 |
| Water treating system | 2,000 |
| Chemical feed | 800 |
| Coal handling system | 70,000 |
| Ash disposal system | 35,000 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-11.(continued)

| | |
|--|--------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | 30,000 |
| Ductwork (not incl. w/boiler) | N.A. |
| Piping | 35,000 |
| Insulation | 25,000 |
| Painting | 5,000 |
| Electrical | 30,000 |
| Buildings | 120,000 |
| Total Installation Costs | \$ 450,900 |
| TOTAL DIRECT COSTS (Equipment + Installation) | \$ 955,400 |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ 95,500 |
| Construction and field expense (10% of direct costs) | 95,500 |
| Construction fees (10% of direct costs) | 95,500 |
| Startup (2% of direct costs) | 19,100 |
| Performance tests (minimum \$2000) | 3,500 |
| TOTAL INDIRECT COSTS | \$ 309,100 |
| Contingencies (20% of direct and indirect costs) | \$ 252,900 |
| Total turnkey costs (Direct + Indirect + Contingencies) | 1,517,400 |
| Land | 2,000 |
| Working capital (25% of total direct operating costs) | 145,800 |
| GRAND TOTAL (Turnkey + Land + Working Capital) | \$ 1,665,200 |

^a Quote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-12. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN LOW-SULFUR
COAL WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|--------------|
| Direct labor | \$ 157,900 |
| Supervision | 68,500 |
| Maintenance labor | 64,100 |
| Maintenance materials | ^a |
| Replacement parts | 60,000 |
| Electricity | 34,300 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 500 |
| Fuel | 182,900 |
| Bottom ash disposal | 12,600 |
| Chemicals | 2,300 |
| Total direct cost | \$ 583,100 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor) | \$ 47,400 |
| Plant (26% of labor, parts & maint.) | 91,100 |
| Total overhead costs | \$ 138,500 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 60,700 |
| Capital recovery factor (10.61% of total turnkey costs) | 161,000 |
| Interest on working capital (10% of working capital) | 14,600 |
| Total capital charges | \$ 236,300 |

TOTAL ANNUALIZED COSTS

\$ 957,900

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-13. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

| CAPITAL COSTS | |
|---|------------------------------------|
| DATE OF ESTIMATE | June 30, 1978 (FOR COSTS INDEXING) |
| EQUIPMENT COSTS | |
| Boiler (with fans and ducts) | \$ 380,200 |
| Stack | 3,000 |
| Instrumentation | Incl. w/boiler |
| Stokers | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerator | 5,200 |
| Heaters | N.A. |
| Boiler feed pumps | 13,400 |
| Condensate systems | 7,700 |
| Water treating system | 8,000 |
| Chemical feed | 1,400 |
| Compressed air system | N.A. |
| Coal handling system | 168,200 |
| Ash disposal system | 122,400 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 709,500 |
| INSTALLATION COSTS, DIRECT | |
| Boiler (including founda- tions and steel) | \$ 129,600 |
| Stack | 1,500 |
| Instrumentation | Incl. w/boiler |
| Stokers | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerator | 2,500 |
| Heaters | N.A. |
| Boiler feed pumps | 3,000 |
| Condensate system | 1,100 |
| Water treating system | 2,000 |
| Chemical feed | 800 |
| Coal handling system | 100,800 |
| Ash disposal system | 50,400 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-13.(continued)

| | |
|--|--------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | 43,200 |
| Ductwork (not incl. w/boiler) | N.A. |
| Piping | 50,400 |
| Insulation | 36,000 |
| Painting | 7,200 |
| Electrical | 30,000 |
| Buildings | 172,800 |
| Total Installation Costs | \$ 631,300 |
| TOTAL DIRECT COSTS (Equipment + Installation) | \$ 1,340,800 |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ 134,100 |
| Construction and field expense (10% of direct costs) | 134,100 |
| Construction fees (10% of direct costs) | 134,100 |
| Startup (2% of direct costs) | 26,800 |
| Performance tests (minimum \$2000) | 3,500 |
| TOTAL INDIRECT COSTS | \$ 432,600 |
| Contingencies (20% of direct and indirect costs) | \$ 354,700 |
| Total turnkey costs (Direct + Indirect + Contingencies) | 2,128,100 |
| Land | 2,000 |
| Working capital (25% of total direct operating costs) | 127,000 |
| GRAND TOTAL (Turnkey + Land + Working Capital) | \$ 2,257,100 |

^a Quote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-14. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING SUBBITUMINOUS
COAL WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

| | |
|--|-------------------|
| DIRECT COST | |
| Direct labor | \$ 157,900 |
| Supervision | 68,500 |
| Maintenance labor | 64,100 |
| Maintenance materials | a |
| Replacement parts | 86,400 |
| Electricity | 49,400 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 500 |
| Fuel | 66,200 |
| Bottom ash disposal | 12,600 |
| Chemicals | 2,300 |
| Total direct cost | \$ 507,900 |
| OVERHEAD | |
| Payroll (30% of direct labor) | \$ 47,400 |
| Plant (26% of labor, parts & maint.) | 98,000 |
| Total overhead costs | \$ 145,400 |
| BYPRODUCT CREDITS | N.A. |
| CAPITAL CHARGES | |
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 85,100 |
| Capital recovery factor (10.61% of total turnkey costs) | 225,800 |
| Interest on working capital (10% of working capital) | 12,700 |
| Total capital charges | \$ 323,600 |
| TOTAL ANNUALIZED COSTS | \$ 976,900 |

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-15. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST

| | |
|----------------------------|------------------------------|
| Boiler (with fans & ducts) | \$ <u>276,000</u> |
| Stack | <u>3,000</u> |
| Instrumentation | <u>Incl. w/boiler</u> |
| Stoker | <u>Incl. w/boiler</u> |
| Feeders | <u>Incl. w/coal handling</u> |
| Crushers | <u>Incl. w/coal handling</u> |
| Deaerators | <u>5,200</u> |
| Heaters | <u>N.A.</u> |
| Boiler feed pumps | <u>13,400</u> |
| Condensate systems | <u>7,700</u> |
| Water treating system | <u>8,000</u> |
| Chemical feed | <u>1,400</u> |
| Compressed air system | <u>N.A.</u> |
| Coal handling system | <u>122,000</u> |
| Ash disposal system | <u>89,000</u> |
| Thawing equipment | <u>N.A.</u> |
| Fuel-oil system | <u>N.A.</u> |
| Total Equipment Cost | \$ <u>525,700</u> |

INSTALLATION COST, DIRECT

| | |
|---|------------------------------|
| Boiler (including founda- tions and steel) | \$ <u>94,000</u> |
| Stack | <u>1,500</u> |
| Instrumentation | <u>Incl. w/boiler</u> |
| Stoker | <u>Incl. w/boiler</u> |
| Feeders | <u>Incl. w/coal handling</u> |
| Crushers | <u>Incl. w/coal handling</u> |
| Deaerators | <u>2,500</u> |
| Heaters | <u>N.A.</u> |
| Boiler feed pumps | <u>3,000</u> |
| Condensate system | <u>1,100</u> |
| Water treating system | <u>2,000</u> |
| Chemical feed | <u>800</u> |
| Coal handling system | <u>73,000</u> |
| Ash disposal system | <u>37,000</u> |
| Thawing equipment | <u>N.A.</u> |
| Fuel-oil system | <u>N.A.</u> |

N.A. - Not applicable.

TABLE A-15. (continued)

| | |
|---|---------------------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | <u>31,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>37,000</u> |
| Insulation | <u>26,000</u> |
| Painting | <u>5,000</u> |
| Electrical | <u>30,000</u> |
| Buildings | <u>125,000</u> |
| Total installation cost | <u>\$ 468,900</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 994,600</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 99,500</u> |
| Construction and field expense (10% of direct costs) | <u>99,500</u> |
| Construction fees (10% of direct costs) | <u>99,500</u> |
| Start-up (2% of direct costs) | <u>19,900</u> |
| Performance tests (minimum \$2000) | <u>3,500</u> |
| TOTAL INDIRECT COSTS | <u>\$ 321,900</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 263,300</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>1,579,800</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>141,200</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u><u>\$1,723,000</u></u> |

N.A. - Not applicable.

TABLE A-16. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|-------------------|
| Direct labor | \$ <u>157,900</u> |
| Supervision | <u>68,500</u> |
| Maintenance labor | <u>64,100</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>62,600</u> |
| Electricity | <u>35,800</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>500</u> |
| Fuel | <u>149,800</u> |
| Bottom ash disposal | <u>23,100</u> |
| Chemicals | <u>2,300</u> |
| Total direct cost | \$ <u>564,600</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | \$ <u>47,400</u> |
| Plant (26% of labor, parts & maint.) | <u>91,800</u> |
| Total overhead costs | \$ <u>139,200</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|-------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>63,200</u> |
| Capital recovery factor (10.61% of total turnkey costs) | <u>167,600</u> |
| Interest on working capital (10% of working capital) | <u>14,100</u> |
| Total capital charges | \$ <u>244,900</u> |

| | |
|------------------------|-------------------|
| TOTAL ANNUALIZED COSTS | \$ <u>948,700</u> |
|------------------------|-------------------|

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-17. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|------------------------------|
| Boiler (with fans & ducts) | \$ <u>579,200</u> |
| Stack | <u>9,500</u> |
| Instrumentation | <u>Incl. w/boiler</u> |
| Stoker | <u>Incl. w/boiler</u> |
| Feeders | <u>Incl. w/coal handling</u> |
| Crushers | <u>Incl. w/coal handling</u> |
| Deaerators | <u>13,500</u> |
| Heaters | <u>N.A.</u> |
| Boiler feed pumps | <u>18,000</u> |
| Condensate systems | <u>8,000</u> |
| Water treating system | <u>12,500</u> |
| Chemical feed | <u>1,400</u> |
| Compressed air system | <u>N.A.</u> |
| Coal handling system | <u>146,300</u> |
| Ash disposal system | <u>128,700</u> |
| Thawing equipment | <u>N.A.</u> |
| Fuel-oil system | <u>N.A.</u> |
| Total Equipment Cost | \$ <u>917,100</u> |

INSTALLATION COST, DIRECT

| | |
|---|------------------------------|
| Boiler (including founda- tions and steel) | \$ <u>193,100</u> |
| Stack | <u>4,700</u> |
| Instrumentation | <u>Incl. w/boiler</u> |
| Stoker | <u>Incl. w/boiler</u> |
| Feeders | <u>Incl. w/coal handling</u> |
| Crushers | <u>Incl. w/coal handling</u> |
| Deaerators | <u>3,000</u> |
| Heaters | <u>N.A.</u> |
| Boiler feed pumps | <u>4,800</u> |
| Condensate system | <u>1,100</u> |
| Water treating system | <u>2,100</u> |
| Chemical feed | <u>1,500</u> |
| Coal handling system | <u>146,300</u> |
| Ash disposal system | <u>58,500</u> |
| Thawing equipment | <u>N.A.</u> |
| Fuel-oil system | <u>N.A.</u> |

N.A. - Not applicable.

TABLE A-17. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|----------------|
| Foundations and supports | <u>70,200</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>52,700</u> |
| Insulation | <u>41,000</u> |
| Painting | <u>7,500</u> |
| Electrical | <u>60,000</u> |
| Buildings | <u>198,900</u> |

| | |
|-------------------------|-------------------|
| Total installation cost | \$ <u>845,400</u> |
|-------------------------|-------------------|

| | |
|--|---------------------|
| TOTAL DIRECT COSTS (equipment + installation) | \$ <u>1,762,500</u> |
|--|---------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|-------------------|
| Engineering (10% of direct costs) | \$ <u>176,300</u> |
| Construction and field expense (10% of direct costs) | <u>176,300</u> |
| Construction fees (10% of direct costs) | <u>176,300</u> |
| Start-up (2% of direct costs) | <u>35,300</u> |
| Performance tests (minimum \$2000) | <u>6,000</u> |

| | |
|----------------------|-------------------|
| TOTAL INDIRECT COSTS | \$ <u>570,200</u> |
|----------------------|-------------------|

| | |
|---|-------------------|
| Contingencies (20% of direct and indirect costs) | \$ <u>466,500</u> |
|---|-------------------|

| | |
|--|------------------|
| Total Turnkey Costs (direct+indirect+contingencies) | <u>2,799,200</u> |
|--|------------------|

| | |
|------|--------------|
| Land | <u>2,000</u> |
|------|--------------|

| | |
|--|----------------|
| Working capital (25% of total direct operating costs) | <u>220,600</u> |
|--|----------------|

| | |
|---|---------------------|
| GRAND TOTAL (turnkey+land+working capital) | \$ <u>3,021,800</u> |
|---|---------------------|

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-18. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|------------|
| Direct labor | \$ 184,300 |
| Supervision | 136,900 |
| Maintenance labor | 128,200 |
| Maintenance materials | a |
| Replacement parts | 99,500 |
| Electricity | 53,200 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 900 |
| Fuel | 233,400 |
| Bottom ash disposal | 42,000 |
| Chemicals | 4,000 |
| Total direct cost | \$ 882,400 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor | \$ 55,300 |
| Plant (26% of labor, parts & maint.) | 142,700 |
| Total overhead costs | \$ 198,000 |

BY-PRODUCT CREDITS N.A.

CAPITAL CHARGES

| | |
|---|------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 112,000 |
| Capital recovery factor (10.61 % of total turnkey costs) | 297,000 |
| Interest on working capital (10% of working capital) | 22,100 |
| Total capital charges | \$ 431,100 |

TOTAL ANNUALIZED COSTS \$ 1,511,500

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-19. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|------------------------------|
| Boiler (with fans & ducts) | \$ <u>495,000</u> |
| Stack | <u>9,500</u> |
| Instrumentation | <u>Incl. w/boiler</u> |
| Stoker | <u>Incl. w/boiler</u> |
| Feeders | <u>Incl. w/coal handling</u> |
| Crushers | <u>Incl. w/coal handling</u> |
| Deaerators | <u>13,500</u> |
| Heaters | <u>N.A.</u> |
| Boiler feed pumps | <u>18,000</u> |
| Condensate systems | <u>8,000</u> |
| Water treating system | <u>12,500</u> |
| Chemical feed | <u>1,400</u> |
| Compressed air system | <u>N.A.</u> |
| Coal handling system | <u>125,000</u> |
| Ash disposal system | <u>110,000</u> |
| Thawing equipment | <u>N.A.</u> |
| Fuel-oil system | <u>N.A.</u> |
| Total Equipment Cost | \$ <u>792,900</u> |

INSTALLATION COST, DIRECT

| | |
|---|------------------------------|
| Boiler (including founda- tions and steel) | \$ <u>165,000</u> |
| Stack | <u>4,700</u> |
| Instrumentation | <u>Incl. w/boiler</u> |
| Stoker | <u>Incl. w/boiler</u> |
| Feeders | <u>Incl. w/coal handling</u> |
| Crushers | <u>Incl. w/coal handling</u> |
| Deaerators | <u>3,000</u> |
| Heaters | <u>N.A.</u> |
| Boiler feed pumps | <u>4,800</u> |
| Condensate system | <u>1,100</u> |
| Water treating system | <u>2,100</u> |
| Chemical feed | <u>1,500</u> |
| Coal handling system | <u>125,000</u> |
| Ash disposal system | <u>50,000</u> |
| Thawing equipment | <u>N.A.</u> |
| Fuel-oil system | <u>N.A.</u> |

N.A. - Not applicable.

TABLE A-19. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|----------------|
| Foundations and supports | <u>60,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>45,000</u> |
| Insulation | <u>35,000</u> |
| Painting | <u>6,400</u> |
| Electrical | <u>60,000</u> |
| Buildings | <u>170,000</u> |

| | |
|-------------------------|-------------------|
| Total installation cost | <u>\$ 733,600</u> |
|-------------------------|-------------------|

TOTAL DIRECT COSTS

| | |
|----------------------------|--------------------|
| (equipment + installation) | <u>\$1,526,500</u> |
|----------------------------|--------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|-------------------|
| Engineering (10% of direct costs) | <u>\$ 152,700</u> |
| Construction and field expense (10% of direct costs) | <u>152,700</u> |
| Construction fees (10% of direct costs) | <u>152,700</u> |
| Start-up (2% of direct costs) | <u>30,500</u> |
| Performance tests (minimum \$2000) | <u>6,000</u> |

| | |
|----------------------|-------------------|
| TOTAL INDIRECT COSTS | <u>\$ 494,600</u> |
|----------------------|-------------------|

Contingencies

| | |
|------------------------------------|-------------------|
| (20% of direct and indirect costs) | <u>\$ 404,200</u> |
|------------------------------------|-------------------|

Total Turnkey Costs

| | |
|---------------------------------|------------------|
| (direct+indirect+contingencies) | <u>2,425,300</u> |
|---------------------------------|------------------|

| | |
|------|--------------|
| Land | <u>2,000</u> |
|------|--------------|

| | |
|--|----------------|
| Working capital (25% of total direct operating costs) | <u>243,400</u> |
|--|----------------|

GRAND TOTAL

| | |
|--------------------------------|--------------------|
| (turnkey+land+working capital) | <u>\$2,670,700</u> |
|--------------------------------|--------------------|

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-20. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|-------------------|
| Direct labor | \$ <u>184,300</u> |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>128,200</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>85,000</u> |
| Electricity | <u>45,400</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>900</u> |
| Fuel | <u>365,800</u> |
| Bottom ash disposal | <u>23,100</u> |
| Chemicals | <u>4,000</u> |
| Total direct cost | \$ <u>973,600</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | \$ <u>55,300</u> |
| Plant (26% of labor, parts & maint.) | <u>138,900</u> |
| Total overhead costs | \$ <u>194,200</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|-------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>97,000</u> |
| Capital recovery factor (10.61 % of total turnkey costs) | <u>257,300</u> |
| Interest on working capital (10% of working capital) | <u>24,300</u> |
| Total capital charges | \$ <u>378,600</u> |

TOTAL ANNUALIZED COSTS \$1,546,400

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-21. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|------------------------------|
| Boiler (with fans & ducts) | \$ <u>712,800</u> |
| Stack | <u>9,500</u> |
| Instrumentation | <u>Incl. w/boiler</u> |
| Stoker | <u>Incl. w/boiler</u> |
| Feeders | <u>Incl. w/coal handling</u> |
| Crushers | <u>Incl. w/coal handling</u> |
| Deaerators | <u>13,500</u> |
| Heaters | <u>N.A.</u> |
| Boiler feed pumps | <u>18,000</u> |
| Condensate systems | <u>8,000</u> |
| Water treating system | <u>12,500</u> |
| Chemical feed | <u>1,400</u> |
| Compressed air system | <u>N.A.</u> |
| Coal handling system | <u>180,000</u> |
| Ash disposal system | <u>158,400</u> |
| Thawing equipment | <u>N.A.</u> |
| Fuel-oil system | <u>N.A.</u> |
| Total Equipment Cost | <u>\$1,114,100</u> |

INSTALLATION COST, DIRECT

| | |
|---|------------------------------|
| Boiler (including founda- tions and steel) | \$ <u>237,600</u> |
| Stack | <u>4,700</u> |
| Instrumentation | <u>Incl. w/boiler</u> |
| Stoker | <u>Incl. w/boiler</u> |
| Feeders | <u>Incl. w/coal handling</u> |
| Crushers | <u>Incl. w/coal handling</u> |
| Deaerators | <u>3,000</u> |
| Heaters | <u>N.A.</u> |
| Boiler feed pumps | <u>4,800</u> |
| Condensate system | <u>1,100</u> |
| Water treating system | <u>2,100</u> |
| Chemical feed | <u>1,500</u> |
| Coal handling system | <u>180,000</u> |
| Ash disposal system | <u>72,000</u> |
| Thawing equipment | <u>N.A.</u> |
| Fuel-oil system | <u>N.A.</u> |

N.A. - Not applicable.

TABLE A-21. (continued)

| INSTALLATION COSTS, DIRECT (cont.) | |
|--|--------------------|
| Foundations and supports | <u>86,400</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>64,800</u> |
| Insulation | <u>50,400</u> |
| Painting | <u>9,200</u> |
| Electrical | <u>60,000</u> |
| Buildings | <u>244,800</u> |
| Total installation cost | <u>\$1,022,400</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$2,136,500</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 213,700</u> |
| Construction and field expense (10% of direct costs) | <u>213,700</u> |
| Construction fees (10% of direct costs) | <u>213,700</u> |
| Start-up (2% of direct costs) | <u>42,700</u> |
| Performance tests (minimum \$2000) | <u>6,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 689,800</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 565,300</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>3,391,600</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>200,500</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u>\$3,594,100</u> |

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-22. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|-------------------|
| Direct labor | \$ <u>184,300</u> |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>128,200</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>122,400</u> |
| Electricity | <u>65,400</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>900</u> |
| Fuel | <u>132,500</u> |
| Bottom ash disposal | <u>27,300</u> |
| Chemicals | <u>4,000</u> |
| Total direct cost | \$ <u>801,900</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | \$ <u>55,300</u> |
| Plant (26% of labor, parts & maint.) | <u>148,700</u> |
| Total overhead costs | \$ <u>204,000</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|-------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>135,700</u> |
| Capital recovery factor (10.61 % of total turnkey costs) | <u>359,800</u> |
| Interest on working capital (10% of working capital) | <u>20,100</u> |
| Total capital charges | \$ <u>515,600</u> |

| | |
|------------------------|---------------------|
| TOTAL ANNUALIZED COSTS | \$ <u>1,521,500</u> |
|------------------------|---------------------|

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-23. ESTIMATED CAPITAL COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|------------------------------|
| Boiler (with fans & ducts) | \$ <u>516,800</u> |
| Stack | <u>9,500</u> |
| Instrumentation | <u>Incl. w/boiler</u> |
| Stoker | <u>Incl. w/boiler</u> |
| Feeders | <u>Incl. w/coal handling</u> |
| Crushers | <u>Incl. w/coal handling</u> |
| Deaerators | <u>13,500</u> |
| Heaters | <u>N.A.</u> |
| Boiler feed pumps | <u>18,000</u> |
| Condensate systems | <u>8,000</u> |
| Water treating system | <u>12,500</u> |
| Chemical feed | <u>1,400</u> |
| Compressed air system | <u>N.A.</u> |
| Coal handling system | <u>130,500</u> |
| Ash disposal system | <u>114,800</u> |
| Thawing equipment | <u>N.A.</u> |
| Fuel-oil system | <u>N.A.</u> |
| Total Equipment Cost | \$ <u>825,000</u> |

INSTALLATION COST, DIRECT

| | |
|---|------------------------------|
| Boiler (including founda- tions and steel) | \$ <u>172,300</u> |
| Stack | <u>4,700</u> |
| Instrumentation | <u>Incl. w/boiler</u> |
| Stoker | <u>Incl. w/boiler</u> |
| Feeders | <u>Incl. w/coal handling</u> |
| Crushers | <u>Incl. w/coal handling</u> |
| Deaerators | <u>3,000</u> |
| Heaters | <u>N.A.</u> |
| Boiler feed pumps | <u>4,800</u> |
| Condensate system | <u>1,100</u> |
| Water treating system | <u>2,100</u> |
| Chemical feed | <u>1,500</u> |
| Coal handling system | <u>130,500</u> |
| Ash disposal system | <u>52,200</u> |
| Thawing equipment | <u>N.A.</u> |
| Fuel-oil system | <u>N.A.</u> |

N.A. - Not applicable.

TABLE A-23. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|----------------|
| Foundations and supports | <u>62,600</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>47,000</u> |
| Insulation | <u>36,500</u> |
| Painting | <u>6,700</u> |
| Electrical | <u>60,000</u> |
| Buildings | <u>177,500</u> |

| | |
|-------------------------|-------------------|
| Total installation cost | <u>\$ 762,500</u> |
|-------------------------|-------------------|

TOTAL DIRECT COSTS

| | |
|----------------------------|--------------------|
| (equipment + installation) | <u>\$1,587,500</u> |
|----------------------------|--------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|-------------------|
| Engineering (10% of direct costs) | <u>\$ 158,800</u> |
| Construction and field expense (10% of direct costs) | <u>158,800</u> |
| Construction fees (10% of direct costs) | <u>158,800</u> |
| Start-up (2% of direct costs) | <u>31,800</u> |
| Performance tests (minimum \$2000) | <u>6,000</u> |

| | |
|----------------------|-------------------|
| TOTAL INDIRECT COSTS | <u>\$ 514,200</u> |
|----------------------|-------------------|

Contingencies

| | |
|------------------------------------|-------------------|
| (20% of direct and indirect costs) | <u>\$ 420,300</u> |
|------------------------------------|-------------------|

Total Turnkey Costs

| | |
|---------------------------------|------------------|
| (direct+indirect+contingencies) | <u>2,522,000</u> |
|---------------------------------|------------------|

Land

| |
|--------------|
| <u>2,000</u> |
|--------------|

| | |
|--|----------------|
| Working capital (25% of total direct operating costs) | <u>234,100</u> |
|--|----------------|

GRAND TOTAL

| | |
|--------------------------------|--------------------|
| (turnkey+land+working capital) | <u>\$2,758,100</u> |
|--------------------------------|--------------------|

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-24. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, WATER-TUBE,
UNDERFEED-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|-------------------|
| Direct labor | \$ <u>184,300</u> |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>128,200</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>88,700</u> |
| Electricity | <u>47,500</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>900</u> |
| Fuel | <u>299,600</u> |
| Bottom ash disposal | <u>46,300</u> |
| Chemicals | <u>4,000</u> |
| Total direct cost | \$ <u>936,400</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor) | \$ <u>55,300</u> |
| Plant (26% of labor, parts & maint.) | <u>139,900</u> |
| Total overhead costs | \$ <u>195,200</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|-------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>100,900</u> |
| Capital recovery factor (10.61 % of total turnkey costs) | <u>267,600</u> |
| Interest on working capital (10% of working capital) | <u>23,400</u> |
| Total capital charges | \$ <u>391,900</u> |

TOTAL ANNUALIZED COSTS \$1,523,500

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-25. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE SPREADER-STOKER BOILER FIRING EASTERN HIGH-SULFUR

COAL WITH A THERMAL INPUT OF 22 MW
(75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 760,500 |
| Stack | 80,000 |
| Instrumentation | 50,000 |
| Stoker | 175,500 |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | 15,900 |
| Heaters | N.A. |
| Boiler feed pumps | 25,300 |
| Condensate systems | 8,700 |
| Water treating system | 15,000 |
| Chemical feed | 1,400 |
| Compressed air system | N.A. |
| Coal handling system | 165,400 |
| Ash disposal system | 136,000 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |

Total Equipment Cost \$ 1,433,700

INSTALLATION COST, DIRECT

| | |
|--|-----------------------|
| Boiler (including foundations and steel) | \$ 491,400 |
| Stack | 20,000 |
| Instrumentation | 15,000 |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | 3,500 |
| Heaters | N.A. |
| Boiler feed pumps | 5,500 |
| Condensate system | 1,300 |
| Water treating system | 2,500 |
| Chemical feed | 1,500 |
| Coal handling system | 175,500 |
| Ash disposal system | 70,200 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-25. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|----------------|
| Foundations and supports | <u>93,600</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>58,500</u> |
| Insulation | <u>46,800</u> |
| Painting | <u>8,200</u> |
| Electrical | <u>75,000</u> |
| Buildings | <u>234,000</u> |

| | |
|-------------------------|--------------------|
| Total installation cost | <u>\$1,302,500</u> |
|-------------------------|--------------------|

| | |
|--|--------------------|
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$2,736,200</u> |
|--|--------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|-------------------|
| Engineering (10% of direct costs) | <u>\$ 273,600</u> |
| Construction and field expense (10% of direct costs) | <u>273,600</u> |
| Construction fees (10% of direct costs) | <u>273,600</u> |
| Start-up (2% of direct costs) | <u>54,700</u> |
| Performance tests (minimum \$2000) | <u>7,000</u> |

| | |
|----------------------|-------------------|
| TOTAL INDIRECT COSTS | <u>\$ 882,500</u> |
|----------------------|-------------------|

| | |
|---|-------------------|
| Contingencies (20% of direct and indirect costs) | <u>\$ 723,700</u> |
|---|-------------------|

| | |
|--|------------------|
| Total Turnkey Costs (direct+indirect+contingencies) | <u>4,342,400</u> |
|--|------------------|

| | |
|------|--------------|
| Land | <u>2,000</u> |
|------|--------------|

| | |
|--|----------------|
| Working capital (25% of total direct operating costs) | <u>243,300</u> |
|--|----------------|

| | |
|---|--------------------|
| GRAND TOTAL (turnkey+land+working capital) | <u>\$4,587,700</u> |
|---|--------------------|

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-26. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL

WITH A THERMAL INPUT OF 22 MW
(75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|------------|
| Direct labor | \$ 210,600 |
| Supervision | 136,900 |
| Maintenance labor | 128,200 |
| Maintenance materials | a |
| Replacement parts | 117,000 |
| Electricity | 57,600 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 1,100 |
| Fuel | 291,700 |
| Bottom ash disposal | 25,200 |
| Chemicals | 4,900 |
| Total direct cost | \$ 973,200 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor | \$ 63,200 |
| Plant (26% of labor, parts & maint.) | 154,100 |
| Total overhead costs | \$ 217,300 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 173,700 |
| Capital recovery factor (10.14 % of total turnkey costs) | 440,300 |
| Interest on working capital (10% of working capital) | 24,300 |
| Total capital charges | \$ 638,300 |

TOTAL ANNUALIZED COSTS \$1,828,800

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-27. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 22 MW
(75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 650,000 |
| Stack | 80,000 |
| Instrumentation | 50,000 |
| Stoker | 150,000 |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | 15,900 |
| Heaters | N.A. |
| Boiler feed pumps | 25,300 |
| Condensate systems | 8,700 |
| Water treating system | 15,000 |
| Chemical feed | 1,400 |
| Compressed air system | N.A. |
| Coal handling system | 141,400 |
| Ash disposal system | 116,200 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 1,253,900 |

INSTALLATION COST, DIRECT

| | |
|--|-----------------------|
| Boiler (including foundations and steel) | \$ 420,000 |
| Stack | 20,000 |
| Instrumentation | 15,000 |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | 3,500 |
| Heaters | N.A. |
| Boiler feed pumps | 5,500 |
| Condensate system | 1,300 |
| Water treating system | 2,500 |
| Chemical feed | 1,500 |
| Coal handling system | 150,000 |
| Ash disposal system | 60,000 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-27. (continued)

| INSTALLATION COSTS, DIRECT (cont.) | |
|--|----------------------|
| Foundations and supports | <u>80,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>50,000</u> |
| Insulation | <u>40,000</u> |
| Painting | <u>7,000</u> |
| Electrical | <u>75,000</u> |
| Buildings | <u>200,000</u> |
| Total installation cost | <u>\$1,131,300</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$2,385,200</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 238,500</u> |
| Construction and field expense (10% of direct costs) | <u>238,500</u> |
| Construction fees (10% of direct costs) | <u>238,500</u> |
| Start-up (2% of direct costs) | <u>47,700</u> |
| Performance tests (minimum \$2000) | <u>7,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 770,200</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 631,100</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>3,786,500</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>275,700</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u>\$4,064,200</u> ✓ |

^a Quote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-28. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE SPREADER-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
COAL WITH A THERMAL INPUT OF 22 MW
(75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|--------------------|
| Direct labor | \$ 210,600 |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>128,200</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>100,000</u> |
| Electricity | <u>49,200</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>1,100</u> |
| Fuel | <u>457,300</u> |
| Bottom ash disposal | <u>14,700</u> |
| Chemicals | <u>4,900</u> |
| Total direct cost | <u>\$1,102,900</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | \$ <u>63,200</u> |
| Plant (26% of labor, parts & maint.) | <u>149,700</u> |
| Total overhead costs | <u>\$ 212,900</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|-------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>151,500</u> |
| Capital recovery factor (10.14 % of total turnkey costs) | <u>384,000</u> |
| Interest on working capital (10% of working capital) | <u>27,600</u> |
| Total capital charges | <u>\$ 563,100</u> |

TOTAL ANNUALIZED COSTS \$1,878,900 ✓

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-29. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 22 MW
(75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 936,000 |
| Stack | 80,000 |
| Instrumentation | 50,000 |
| Stoker | 216,000 |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | 15,900 |
| Heaters | N.A. |
| Boiler feed pumps | 25,300 |
| Condensate systems | 8,700 |
| Water treating system | 15,000 |
| Chemical feed | 1,400 |
| Compressed air system | N.A. |
| Coal handling system | 203,600 |
| Ash disposal system | 167,300 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 1,719,200 |

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 601,000 |
| Stack | 20,000 |
| Instrumentation | 15,000 |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | 3,500 |
| Heaters | N.A. |
| Boiler feed pumps | 5,500 |
| Condensate system | 1,300 |
| Water treating system | 2,500 |
| Chemical feed | 1,500 |
| Coal handling system | 216,000 |
| Ash disposal system | 86,400 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-29. (continued)

| INSTALLATION COSTS, DIRECT (cont.) | |
|--|---------------------|
| Foundations and supports | <u>115,200</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>72,000</u> |
| Insulation | <u>57,600</u> |
| Painting | <u>10,100</u> |
| Electrical | <u>75,000</u> |
| Buildings | <u>288,000</u> |
| Total installation cost | \$ <u>1,570,600</u> |
| TOTAL DIRECT COSTS (equipment + installation) | \$ <u>3,289,800</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ <u>329,000</u> |
| Construction and field expense (10% of direct costs) | <u>329,000</u> |
| Construction fees (10% of direct costs) | <u>329,000</u> |
| Start-up (2% of direct costs) | <u>65,800</u> |
| Performance tests (minimum \$2000) | <u>7,000</u> |
| TOTAL INDIRECT COSTS | \$ <u>1,059,800</u> |
| Contingencies (20% of direct and indirect costs) | \$ <u>869,900</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>5,219,500</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>219,200</u> |
| GRAND TOTAL (turnkey+land+working capital) | \$ <u>5,440,700</u> |

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-30. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE
SPREADER-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 22.0 MW
(75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|------------|
| Direct labor | \$ 210,600 |
| Supervision | 136,900 |
| Maintenance labor | 128,200 |
| Maintenance materials | a |
| Replacement parts | 144,000 |
| Electricity | 70,900 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 1,100 |
| Fuel | 165,600 |
| Bottom ash disposal | 14,700 |
| Chemicals | 4,900 |
| Total direct cost | \$ 876,900 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor | \$ 63,200 |
| Plant (26% of labor, parts & maint.) | 161,100 |
| Total overhead costs | \$ 224,300 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 208,800 |
| Capital recovery factor (10.14 % of total turnkey costs) | 529,300 |
| Interest on working capital (10% of working capital) | 21,900 |
| Total capital charges | \$ 760,000 |

TOTAL ANNUALIZED COSTS \$1,861,200 ✓

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-31. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED WATER TUBE,
SPREADER-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 22 MW
(75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 678,600 |
| Stack | 80,000 |
| Instrumentation | 50,000 |
| Stoker | 156,600 |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | 15,900 |
| Heaters | N.A. |
| Boiler feed pumps | 25,300 |
| Condensate systems | 8,700 |
| Water treating system | 15,000 |
| Chemical feed | 1,400 |
| Compressed air system | N.A. |
| Coal handling system | 147,600 |
| Ash disposal system | 121,300 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$1,300,400 |

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 438,500 |
| Stack | 20,000 |
| Instrumentation | 15,000 |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | 3,500 |
| Heaters | N.A. |
| Boiler feed pumps | 5,500 |
| Condensate system | 1,300 |
| Water treating system | 2,500 |
| Chemical feed | 1,500 |
| Coal handling system | 156,600 |
| Ash disposal system | 62,600 |
| Thawing equipment | N.A. |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-31. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|----------------|
| Foundations and supports | <u>83,500</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>52,200</u> |
| Insulation | <u>41,800</u> |
| Painting | <u>7,300</u> |
| Electrical | <u>75,000</u> |
| Buildings | <u>208,800</u> |

| | |
|-------------------------|--------------------|
| Total installation cost | <u>\$1,175,600</u> |
|-------------------------|--------------------|

TOTAL DIRECT COSTS

| | |
|----------------------------|--------------------|
| (equipment + installation) | <u>\$2,476,000</u> |
|----------------------------|--------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|-------------------|
| Engineering (10% of direct costs) | <u>\$ 247,600</u> |
| Construction and field expense (10% of direct costs) | <u>247,600</u> |
| Construction fees (10% of direct costs) | <u>247,600</u> |
| Start-up (2% of direct costs) | <u>49,500</u> |
| Performance tests (minimum \$2000) | <u>7,000</u> |

| | |
|----------------------|-------------------|
| TOTAL INDIRECT COSTS | <u>\$ 799,300</u> |
|----------------------|-------------------|

Contingencies

| | |
|------------------------------------|-------------------|
| (20% of direct and indirect costs) | <u>\$ 655,100</u> |
|------------------------------------|-------------------|

Total Turnkey Costs

| | |
|---------------------------------|------------------|
| (direct+indirect+contingencies) | <u>3,930,400</u> |
|---------------------------------|------------------|

Land

| |
|--------------|
| <u>2,000</u> |
|--------------|

| | |
|--|----------------|
| Working capital (25% of total direct operating costs) | <u>259,800</u> |
|--|----------------|

GRAND TOTAL

| | |
|--------------------------------|---------------------------|
| (turnkey+land+working capital) | <u><u>\$4,192,200</u></u> |
|--------------------------------|---------------------------|

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE A-32. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 22 MW
(75 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|---------------------|
| Direct labor | \$ <u>210,600</u> |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>128,200</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>104,400</u> |
| Electricity | <u>51,400</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>1,100</u> |
| Fuel | <u>374,500</u> |
| Bottom ash disposal | <u>27,300</u> |
| Chemicals | <u>4,900</u> |
| Total direct cost | \$ <u>1,039,300</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | \$ <u>63,200</u> |
| Plant (26% of labor, parts & maint.) | <u>150,800</u> |
| Total overhead costs | \$ <u>214,000</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|-------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>157,200</u> |
| Capital recovery factor (10.14 % of total turnkey costs) | <u>398,500</u> |
| Interest on working capital (10% of working capital) | <u>26,000</u> |
| Total capital charges | \$ <u>581,700</u> |

TOTAL ANNUALIZED COSTS \$1,835,000

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-33. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL
WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 450 psig/600°F design)

| CAPITAL COSTS | |
|------------------------------|------------------------------------|
| DATE OF ESTIMATE | June 30, 1978 (FOR COSTS INDEXING) |
| EQUIPMENT COST ^a | |
| Boiler (with fans and ducts) | \$ 1,753,800 |
| Stack | 300,000 |
| Instrumentation | 113,500 |
| Stokers | 227,600 |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerator | 21,600 |
| Heaters | N.A. |
| Boiler feed pumps | 44,500 |
| Condensate systems | 9,200 |
| Water treating system | 18,000 |
| Chemical feed | 1,500 |
| Compressed air system | N.A. |
| Coal handling system | 282,300 |
| Ash disposal system | 167,500 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 2,939,500 |

INSTALLATION COSTS, DIRECT

| | |
|--|----------------------------|
| Boiler (including foundations and steel) | \$ 936,000 |
| Stack | 50,000 |
| Instrumentation | 25,000 |
| Pulverizers | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerator | 4,000 |
| Heaters | N.A. |
| Boiler feed pumps | 7,000 |
| Condensate system | 1,500 |
| Water treating system | 3,000 |
| Chemical feed | 1,500 |
| Coal handling system | 292,500 (incl. site prep.) |
| Ash disposal system | 117,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-33. (continued)

| | |
|--|--------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | 175,500 |
| Ductwork (not incl. w/boiler) | N.A. |
| Piping | 81,900 |
| Insulation | 87,800 |
| Painting | 11,700 |
| Electrical | 150,000 |
| Buildings | 409,500 |
| Total Installation Costs | \$ 2,353,900 |
| TOTAL DIRECT COSTS (Equipment + Installation) | \$ 5,293,400 |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ 529,300 |
| Construction and field expense (10% of direct costs) | 529,300 |
| Construction fees (10% of direct costs) | 529,300 |
| Startup (2% of direct costs) | 105,900 |
| Performance tests | 10,000 |
| TOTAL INDIRECT COSTS | \$ 1,703,800 |
| Contingencies (20% of direct and indirect costs) | \$ 1,399,400 |
| Total turnkey costs (Direct + Indirect + Contingencies) | 8,396,600 |
| Land | 2,000 |
| Working capital (25% of total direct operating costs) | 385,600 |
| GRAND TOTAL (Turnkey + Land + Working Capital) | \$ 8,784,200 |

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-34. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED
WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN HIGH-SULFUR
COAL WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 450 psig/600°F design)

DIRECT COST

| | |
|-----------------------|-------------|
| Direct labor | \$ 315,900 |
| Supervision | 136,900 |
| Maintenance labor | 128,200 |
| Maintenance materials | a |
| Replacement parts | 234,000 |
| Electricity | 85,200 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 2,300 |
| Fuel | 583,400 |
| Bottom ash disposal | 50,500 |
| Chemicals | 6,000 |
| Total direct cost | \$1,542,400 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor) | \$ 94,800 |
| Plant (26% of labor, parts & maint.) | 211,900 |
| Total overhead costs | \$ 306,700 |

BYPRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|-------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 335,900 |
| Capital recovery factor (10.14% of total turnkey costs) | 851,400 |
| Interest on working capital (10% of working capital) | 38,600 |
| Total capital charges | \$1,225,900 |

TOTAL ANNUALIZED COSTS

\$3,075,000 ✓

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-35. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN LOW-
SULFUR COAL WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 450 psig/600°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

| | |
|------------------------------|-----------------------|
| Boiler (with fans and ducts) | \$ 1,499,000 |
| Stack | 300,000 |
| Instrumentation | 113,500 |
| Stokers | 194,500 |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerator | 21,600 |
| Heaters | N.A. |
| Boiler feed pumps | 44,500 |
| Condensate systems | 9,200 |
| Water treating system | 18,000 |
| Chemical feed | 1,500 |
| Compressed air system | N.A. |
| Coal handling system | 241,300 |
| Ash disposal system | 143,200 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 2,586,300 |

INSTALLATION COSTS, DIRECT

| | |
|---|----------------------------|
| Boiler (including founda- tions and steel) | \$ 800,000 |
| Stack | 50,000 |
| Instrumentation | 25,000 |
| Pulverizers | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerator | 4,000 |
| Heaters | N.A. |
| Boiler feed pumps | 7,000 |
| Condensate system | 1,500 |
| Water treating system | 3,000 |
| Chemical feed | 1,500 |
| Coal handling system | 250,000 (incl. site prep.) |
| Ash disposal system | 100,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-35. (continued)

| | |
|--|----------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | 150,000 |
| Ductwork k (not incl. w/boiler) | N.A. |
| Piping | 70,000 |
| Insulation | 75,000 |
| Painting | 10,000 |
| Electrical | 150,000 |
| Buildings | 350,000 |
| Total Installation Costs | \$ 2,047,000 |
| TOTAL DIRECT COSTS (Equipment + Installation) | \$ 4,633,300 |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ 463,300 |
| Construction and field expense (10% of direct costs) | 463,300 |
| Construction fees (10% of direct costs) | 463,300 |
| Startup (2% of direct costs) | 92,700 |
| Performance tests (minimum \$2000) | 10,000 |
| TOTAL INDIRECT COSTS | \$ 1,492,600 |
| Contingencies (20% of direct and indirect costs) | \$ 1,225,200 |
| Total turnkey costs (Direct + Indirect + Contingencies) | 7,351,100 |
| Land | 2,000 |
| Working capital (25% of total direct operating costs) | 451,000 |
| GRAND TOTAL (Turnkey + Land + Working Capital) | \$ 7,804,100 ✓ |

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-36. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN LOW-
SULFUR COAL WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 450 psig/600°F design)

| | |
|--|---------------------|
| DIRECT COST | |
| Direct labor | \$ 315,900 |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>128,200</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>200,000</u> |
| Electricity | <u>72,800</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>2,300</u> |
| Fuel | <u>914,500</u> |
| Bottom ash disposal | <u>27,300</u> |
| Chemicals | <u>6,000</u> |
| Total direct cost | <u>\$1,803,900</u> |
| OVERHEAD | |
| Payroll (30% of direct labor) | \$ <u>94,800</u> |
| Plant (26% of labor, parts & maint.) | <u>203,100</u> |
| Total overhead costs | \$ <u>297,900</u> |
| BYPRODUCT CREDITS | <u>N.A.</u> |
| CAPITAL CHARGES | |
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>294,000</u> |
| Capital recovery factor (10.14% of total turnkey costs) | <u>745,400</u> |
| Interest on working capital (10% of working capital) | <u>45,100</u> |
| Total capital charges | \$ <u>1,084,500</u> |
| TOTAL ANNUALIZED COSTS | <u>\$ 3,186,300</u> |

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-37. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILER FIRING SUBBITUMINOUS
COAL WITH A THERMAL INPUT OF 44 MW
(150×10^6 Btu/h; 450 psig/600°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|------------------------------|-----------------------|
| Boiler (with fans and ducts) | \$ 2,158,600 |
| Stack | 300,000 |
| Instrumentation | 113,500 |
| Stokers | 280,100 |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerator | 21,600 |
| Heaters | N.A. |
| Boiler feed pumps | 44,500 |
| Condensate systems | 9,200 |
| Water treating system | 18,000 |
| Chemical feed | 1,500 |
| Compressed air system | N.A. |
| Coal handling system | 347,500 |
| Ash disposal system | 206,200 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

Total Equipment Cost

\$ 3,500,700

INSTALLATION COSTS, DIRECT

| | |
|---|----------------------------|
| Boiler (including founda- tions and steel) | \$ 1,152,000 |
| Stack | 50,000 |
| Instrumentation | 25,000 |
| Pulverizers | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerator | 4,000 |
| Heaters | N.A. |
| Boiler feed pumps | 7,000 |
| Condensate system | 1,500 |
| Water treating system | 3,000 |
| Chemical feed | 1,500 |
| Coal handling system | 360,000 (incl. site prep.) |
| Ash disposal system | 144,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-37. (continued)

| | |
|--|--------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | 216,000 |
| Ductwork (not incl. w/boiler) | N.A. |
| Piping | 100,800 |
| Insulation | 108,000 |
| Painting | 14,400 |
| Electrical | 150,000 |
| Buildings | 504,000 |
| Total Installation Costs | \$ 2,841,200 |
| TOTAL DIRECT COSTS (Equipment + Installation) | \$ 6,341,900 |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ 634,200 |
| Construction and field expense (10% of direct costs) | 634,200 |
| Construction fees (10% of direct costs) | 634,200 |
| Startup (2% of direct costs) | 126,800 |
| Performance tests (minimum \$2000) | 10,000 |
| TOTAL INDIRECT COSTS | \$ 2,039,400 |
| Contingencies (20% of direct and indirect costs) | \$ 1,676,300 |
| Total turnkey costs (Direct + Indirect + Contingencies) | 10,057,600 |
| Land | 2,000 |
| Working capital (25% of total direct operating costs) | 336,200 |
| GRAND TOTAL (Turnkey + Land + Working Capital) | \$10,395,800 |

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-38. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, SPREADER-STOKER BOILER FIRING SUBBITUMINOUS
COAL WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 450 psig/600°F design)

DIRECT COST

| | |
|-----------------------|-------------|
| Direct labor | \$ 315,900 |
| Supervision | 136,900 |
| Maintenance labor | 128,200 |
| Maintenance materials | a |
| Replacement parts | 288,000 |
| Electricity | 104,800 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 2,300 |
| Fuel | 331,100 |
| Bottom ash disposal | 31,500 |
| Chemicals | 6,000 |
| Total direct cost | \$1,344,700 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor) | \$ 94,800 |
| Plant (26% of labor, parts & maint.) | 225,900 |
| Total overhead costs | \$ 320,700 |

BYPRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|--------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 402,300 |
| Capital recovery factor (10.14% of total turnkey costs) | 1,019,800 |
| Interest on working capital (10% of working capital) | 33,600 |
| Total capital charges | \$ 1,455,700 |

| | |
|------------------------|--------------|
| TOTAL ANNUALIZED COSTS | \$ 3,121,100 |
|------------------------|--------------|

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-39. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 44.0 MW (150 x 10⁶ Btu/h; 450 psig/600°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 1,565,000 |
| Stack | 300,000 |
| Instrumentation | 113,500 |
| Stoker | 203,000 |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | 21,600 |
| Heaters | N.A. |
| Boiler feed pumps | 44,500 |
| Condensate systems | 9,200 |
| Water treating system | 18,000 |
| Chemical feed | 1,500 |
| Compressed air system | N.A. |
| Coal handling system | 252,000 |
| Ash disposal system | 150,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 2,678,300 |

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 835,000 |
| Stack | 50,000 |
| Instrumentation | 25,000 |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | 4,000 |
| Heaters | N.A. |
| Boiler feed pumps | 7,000 |
| Condensate system | 1,500 |
| Water treating system | 3,000 |
| Chemical feed | 1,500 |
| Coal handling system | 261,000 |
| Ash disposal system | 104,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-39. (continued)

| INSTALLATION COSTS, DIRECT (cont.) | |
|--|---------------------|
| Foundations and supports | <u>157,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>73,000</u> |
| Insulation | <u>78,000</u> |
| Painting | <u>10,000</u> |
| Electrical | <u>150,000</u> |
| Buildings | <u>365,000</u> |
| Total installation cost | <u>\$ 2,125,000</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 4,803,300</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 480,300</u> |
| Construction and field expense (10% of direct costs) | <u>480,300</u> |
| Construction fees (10% of direct costs) | <u>480,300</u> |
| Start-up (2% of direct costs) | <u>96,100</u> |
| Performance tests (minimum \$2000) | <u>10,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 1,547,000</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 1,270,100</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>7,620,400</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>419,500</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u>\$ 8,041,900</u> |

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-40. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 44.0 MW
(150 x 10⁶ Btu/h; 450 psig/600°F design)

DIRECT COST

| | |
|-----------------------|--------------------|
| Direct labor | \$ 315,900 |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>128,200</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>208,800</u> |
| Electricity | <u>76,100</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>2,300</u> |
| Fuel | <u>749,000</u> |
| Bottom ash disposal | <u>54,700</u> |
| Chemicals | <u>6,000</u> |
| Total direct cost | <u>\$1,677,900</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | \$ <u>94,800</u> |
| Plant (26% of labor, parts & maint.) | <u>205,300</u> |
| Total overhead costs | <u>\$ 300,100</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|--------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>304,800</u> |
| Capital recovery factor (10.14 % of total turnkey costs) | <u>772,700</u> |
| Interest on working capital (10% of working capital) | <u>42,000</u> |
| Total capital charges | <u>\$1,119,500</u> |

| | |
|------------------------|--------------------|
| TOTAL ANNUALIZED COSTS | <u>\$3,097,500</u> |
|------------------------|--------------------|

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-41. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 2,049,000 |
| Stack | 375,000 |
| Instrumentation | 123,700 |
| Stoker | 258,000 |
| Feeders | 117,000 |
| Crushers | Incl. w/coal handling |
| Deaerators | 28,000 |
| Heaters | N.A. |
| Boiler feed pumps | 58,000 |
| Condensate systems | 18,000 |
| Water treating system | 20,000 |
| Chemical feed | 1,500 |
| Compressed air system | 18,000 |
| Coal handling system | 316,000 |
| Ash disposal system | 205,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 3,587,200 |

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 1,082,000 |
| Stack | 65,000 |
| Instrumentation | 40,000 |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | 6,000 |
| Heaters | N.A. |
| Boiler feed pumps | 8,500 |
| Condensate system | 2,000 |
| Water treating system | 3,500 |
| Chemical feed | 1,500 |
| Coal handling system | 322,000 |
| Ash disposal system | 146,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-41. (continued)

| | |
|---|----------------------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | <u>199,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>100,000</u> |
| Insulation | <u>100,000</u> |
| Painting | <u>12,000</u> |
| Electrical | <u>165,000</u> |
| Buildings | <u>468,000</u> |
| Total installation cost | <u>\$2,720,500</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$6,307,700</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 630,800</u> |
| Construction and field expense (10% of direct costs) | <u>630,800</u> |
| Construction fees (10% of direct costs) | <u>630,800</u> |
| Start-up (2% of direct costs) | <u>126,200</u> |
| Performance tests (minimum \$2000) | <u>10,000</u> |
| TOTAL INDIRECT COSTS | <u>\$2,028,600</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$1,667,300</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>10,003,600</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>504,600</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u><u>\$10,510,200</u></u> |

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-42. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN HIGH-SULFUR COAL
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|---------------------|
| Direct labor | \$ <u>421,200</u> |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>192,200</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>304,200</u> |
| Electricity | <u>110,200</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>3,000</u> |
| Fuel | <u>777,900</u> |
| Bottom ash disposal | <u>65,200</u> |
| Chemicals | <u>7,500</u> |
| Total direct cost | \$ <u>2,018,300</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor) | \$ <u>126,400</u> |
| Plant (26% of labor, parts & maint.) | <u>274,200</u> |
| Total overhead costs | \$ <u>400,600</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|---------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>400,100</u> |
| Capital recovery factor (10.14% of total turnkey costs) | <u>1,014,400</u> |
| Interest on working capital (10% of working capital) | <u>50,500</u> |
| Total capital charges | \$ <u>1,465,000</u> |

TOTAL ANNUALIZED COSTS \$3,883,900

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-43. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 1,751,200 |
| Stack | 375,000 |
| Instrumentation | 123,700 |
| Stoker | 220,800 |
| Feeders | 100,000 |
| Crushers | Incl. w/coal handling |
| Deaerators | 28,000 |
| Heaters | N.A. |
| Boiler feed pumps | 58,000 |
| Condensate systems | 18,000 |
| Water treating system | 20,000 |
| Chemical feed | 1,500 |
| Compressed air system | 15,000 |
| Coal handling system | 270,000 |
| Ash disposal system | 175,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 3,156,200 |

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 925,000 |
| Stack | 65,000 |
| Instrumentation | 40,000 |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | 6,000 |
| Heaters | N.A. |
| Boiler feed pumps | 8,500 |
| Condensate system | 2,000 |
| Water treating system | 3,500 |
| Chemical feed | 1,500 |
| Coal handling system | 275,000 |
| Ash disposal system | 125,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-43. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|----------------|
| Foundations and supports | <u>170,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>85,000</u> |
| Insulation | <u>85,000</u> |
| Painting | <u>10,000</u> |
| Electrical | <u>165,000</u> |
| Buildings | <u>400,000</u> |

| | |
|-------------------------|---------------------|
| Total installation cost | <u>\$ 2,366,500</u> |
|-------------------------|---------------------|

TOTAL DIRECT COSTS

| | |
|----------------------------|---------------------|
| (equipment + installation) | <u>\$ 5,522,700</u> |
|----------------------------|---------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|-------------------|
| Engineering (10% of direct costs) | <u>\$ 552,300</u> |
| Construction and field expense (10% of direct costs) | <u>552,300</u> |
| Construction fees (10% of direct costs) | <u>552,300</u> |
| Start-up (2% of direct costs) | <u>110,500</u> |
| Performance tests (minimum \$2000) | <u>10,000</u> |

| | |
|----------------------|---------------------|
| TOTAL INDIRECT COSTS | <u>\$ 1,777,400</u> |
|----------------------|---------------------|

Contingencies

| | |
|------------------------------------|---------------------|
| (20% of direct and indirect costs) | <u>\$ 1,460,000</u> |
|------------------------------------|---------------------|

Total Turnkey Costs

| | |
|---------------------------------|------------------|
| (direct+indirect+contingencies) | <u>8,760,100</u> |
|---------------------------------|------------------|

Land

| |
|--------------|
| <u>2,000</u> |
|--------------|

| | |
|--|----------------|
| Working capital (25% of total direct operating costs) | <u>593,100</u> |
|--|----------------|

GRAND TOTAL

| | |
|--------------------------------|---------------------------|
| (turnkey+land+working capital) | <u><u>\$9,355,200</u></u> |
|--------------------------------|---------------------------|

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-44. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN LOW-SULFUR COAL
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|--------------------|
| Direct labor | \$ <u>421,200</u> |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>192,200</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>260,000</u> |
| Electricity | <u>94,200</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>3,000</u> |
| Fuel | <u>1,219,400</u> |
| Bottom ash disposal | <u>37,800</u> |
| Chemicals | <u>7,500</u> |
| Total direct cost | <u>\$2,372,200</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | \$ <u>126,400</u> |
| Plant (26% of labor, parts & maint.) | <u>262,700</u> |
| Total overhead costs | <u>\$ 389,100</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|--------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>350,400</u> |
| Capital recovery factor (10.14 % of total turnkey costs) | <u>888,300</u> |
| Interest on working capital (10% of working capital) | <u>59,300</u> |
| Total capital charges | <u>\$1,298,000</u> |

TOTAL ANNUALIZED COSTS \$4,059,300

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-45. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 2,522,000 |
| Stack | 375,000 |
| Instrumentation | 123,700 |
| Stoker | 318,000 |
| Feeders | 144,000 |
| Crushers | Incl. w/coal handling |
| Deaerators | 28,000 |
| Heaters | N.A. |
| Boiler feed pumps | 58,000 |
| Condensate systems | 18,000 |
| Water treating system | 20,000 |
| Chemical feed | 1,500 |
| Compressed air system | 22,000 |
| Coal handling system | 389,000 |
| Ash disposal system | 252,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 4,271,200 |

INSTALLATION COST, DIRECT

| | |
|--|-----------------------|
| Boiler (including foundations and steel) | \$ 1,332,000 |
| Stack | 65,000 |
| Instrumentation | 40,000 |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | 6,000 |
| Heaters | N.A. |
| Boiler feed pumps | 8,500 |
| Condensate system | 2,000 |
| Water treating system | 3,500 |
| Chemical feed | 1,500 |
| Coal handling system | 396,000 |
| Ash disposal system | 180,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-45. (continued)

| | |
|---|---------------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | <u>245,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>122,000</u> |
| Insulation | <u>122,000</u> |
| Painting | <u>14,000</u> |
| Electrical | <u>165,000</u> |
| Buildings | <u>576,000</u> |
| Total installation cost | <u>\$3,278,500</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$7,549,700</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 755,000</u> |
| Construction and field expense (10% of direct costs) | <u>755,000</u> |
| Construction fees (10% of direct costs) | <u>755,000</u> |
| Start-up (2% of direct costs) | <u>151,000</u> |
| Performance tests (minimum \$2000) | <u>10,000</u> |
| TOTAL INDIRECT COSTS | <u>\$2,426,000</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$1,995,100</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>11,970,800</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>438,600</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u>\$12,411,400</u> |

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-46. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING SUBBITUMINOUS COAL
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|-------------|
| Direct labor | \$ 421,200 |
| Supervision | 136,900 |
| Maintenance labor | 192,200 |
| Maintenance materials | a |
| Replacement parts | 374,400 |
| Electricity | 135,700 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 3,000 |
| Fuel | 441,500 |
| Bottom ash disposal | 42,000 |
| Chemicals | 7,500 |
| Total direct cost | \$1,754,400 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor | \$ 126,400 |
| Plant (26% of labor, parts & maint.) | 292,400 |
| Total overhead costs | \$ 418,800 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|-------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 478,800 |
| Capital recovery factor (10.14 % of total turnkey costs) | 1,213,800 |
| Interest on working capital (10% of working capital) | 43,900 |
| Total capital charges | \$1,736,500 |

TOTAL ANNUALIZED COSTS \$3,909,700

a Included with replacement parts.
N.A. - Not applicable.

TABLE A-47. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 58.6 MW (200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 1,828,000 |
| Stack | 375,000 |
| Instrumentation | 123,700 |
| Stoker | 231,000 |
| Feeders | 104,000 |
| Crushers | Incl. w/coal handling |
| Deaerators | 28,000 |
| Heaters | N.A. |
| Boiler feed pumps | 58,000 |
| Condensate systems | 18,000 |
| Water treating system | 20,000 |
| Chemical feed | 1,500 |
| Compressed air system | 16,000 |
| Coal handling system | 282,000 |
| Ash disposal system | 183,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 3,268,200 |

INSTALLATION COST, DIRECT

| | |
|--|-----------------------|
| Boiler (including foundations and steel) | \$ 966,000 |
| Stack | 65,000 |
| Instrumentation | 40,000 |
| Stoker | Incl. w/boiler |
| Feeders | Incl. w/coal handling |
| Crushers | Incl. w/coal handling |
| Deaerators | 6,000 |
| Heaters | N.A. |
| Boiler feed pumps | 8,500 |
| Condensate system | 2,000 |
| Water treating system | 3,500 |
| Chemical feed | 1,500 |
| Coal handling system | 287,000 |
| Ash disposal system | 131,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-47. (continued)

| | |
|---|----------------------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | <u>178,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>89,000</u> |
| Insulation | <u>89,000</u> |
| Painting | <u>10,000</u> |
| Electrical | <u>165,000</u> |
| Buildings | <u>418,000</u> |
| Total installation cost | <u>\$ 2,459,500</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 5,727,700</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 572,800</u> |
| Construction and field expense (10% of direct costs) | <u>572,800</u> |
| Construction fees (10% of direct costs) | <u>572,800</u> |
| Start-up (2% of direct costs) | <u>114,600</u> |
| Performance tests (minimum \$2000) | <u>10,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 1,843,000</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 1,514,100</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>9,084,800</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>550,700</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u><u>\$ 9,637,500</u></u> |

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-48. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED, WATER-TUBE, SPREADER-STOKER BOILER FIRING EASTERN MEDIUM-SULFUR COAL
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

| | |
|---|--------------------|
| DIRECT COST | |
| Direct labor | \$ 421,200 |
| Supervision | 136,900 |
| Maintenance labor | 192,200 |
| Maintenance materials | a |
| Replacement parts | 271,400 |
| Electricity | 98,400 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 3,000 |
| Fuel | 998,600 |
| Bottom ash disposal | 73,600 |
| Chemicals | 7,500 |
| Total direct cost | \$2,202,800 |
| OVERHEAD | |
| Payroll (30% of direct labor) | \$ 126,400 |
| Plant (26% of labor, parts & maint.) | 265,600 |
| Total overhead costs | \$ 392,000 |
| BY-PRODUCT CREDITS | N.A. |
| CAPITAL CHARGES | |
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 363,400 |
| Capital recovery factor (10.14 % of total turnkey costs) | 921,200 |
| Interest on working capital (10% of working capital) | 55,100 |
| Total capital charges | \$1,339,700 |
| TOTAL ANNUALIZED COSTS | \$3,934,500 |

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-49. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
HIGH-SULFUR COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

| | |
|------------------------------|-----------------------|
| Boiler (with fans and ducts) | \$ 2,492,100 |
| Stack | 365,000 |
| Instrumentation | 228,000 |
| Pulverizers | 613,100 |
| Feeders | 128,700 |
| Crushers | Incl. w/coal handling |
| Deaerator | 29,000 |
| Heaters | Incl. w/boiler |
| Boiler feed pumps | 58,000 |
| Condensate systems | 16,300 |
| Water treating system | 20,000 |
| Chemical feed | 1,500 |
| Compressed air system | 23,400 |
| Coal handling system | 308,800 |
| Ash disposal system | 210,600 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

Total Equipment Cost \$ 4,494,500

INSTALLATION COSTS, DIRECT

| | |
|---|----------------------------|
| Boiler (including founda- tions and steel) | \$ 1,270,000 |
| Stack | 60,000 |
| Instrumentation | 35,000 |
| Pulverizers | Incl. w/boiler |
| Feeders | Incl. w/boiler |
| Crushers | Incl. w/coal handling |
| Deaerator | 5,000 |
| Heaters | Incl. w/boiler |
| Boiler feed pumps | 8,000 |
| Condensate system | 2,000 |
| Water treating system | 3,500 |
| Chemical feed | 1,500 |
| Coal handling system | 321,800 (incl. site prep.) |
| Ash disposal system | 140,400 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-49. (continued)

| | |
|--|--------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | 210,600 |
| Duct work (not incl. w/boiler) | N.A. |
| Piping | 93,600 |
| Insulation | 93,600 |
| Painting | 11,700 |
| Electrical | 160,000 |
| Buildings | 444,600 |
| Total Installation Costs | \$ 2,861,300 |
| TOTAL DIRECT COSTS (Equipment + Installation) | \$ 7,355,800 |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ 735,600 |
| Construction and field expense (10% of direct costs) | 735,600 |
| Construction fees (10% of direct costs) | 735,600 |
| Startup (2% of direct costs) | 147,100 |
| Performance tests (minimum \$2000) | 10,000 |
| TOTAL INDIRECT COSTS | \$ 2,363,900 |
| Contingencies (20% of direct and indirect costs) | \$ 1,943,900 |
| Total turnkey costs (Direct + Indirect + Contingencies) | 11,663,600 |
| Land | 2,000 |
| Working capital (25% of total direct operating costs) | 536,800 |
| GRAND TOTAL (Turnkey + Land + Working Capital) | \$12,202,400 |

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. /- Not applicable.

TABLE A-50. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED COAL-FIRED BOILER FIRING EASTERN
HIGH-SULFUR COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|---------------------|
| Direct labor | \$ <u>421,200</u> |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>192,200</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>292,500</u> |
| Electricity | <u>278,300</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>3,000</u> |
| Fuel | <u>777,900</u> |
| Bottom ash disposal | <u>37,800</u> |
| Chemicals | <u>7,500</u> |
| Total direct cost | \$ <u>2,147,300</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor) | \$ <u>126,400</u> |
| Plant (26% of labor, parts & maint.) | <u>271,100</u> |
| Total overhead costs | \$ <u>397,500</u> |

BYPRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|---------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>466,500</u> |
| Capital recovery factor (10.14% of total turnkey costs) | <u>1,182,700</u> |
| Interest on working capital (10% of working capital) | <u>53,700</u> |
| Total capital charges | \$ <u>1,702,900</u> |

| | |
|-------------------------------|---------------------|
| TOTAL ANNUALIZED COSTS | \$ <u>4,247,700</u> |
|-------------------------------|---------------------|

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-51. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
LOW-SULFUR COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

| | |
|------------------------------|-----------------------|
| Boiler (with fans and ducts) | \$ 2,130,000 |
| Stack | 365,000 |
| Instrumentation | 228,000 |
| Pulverizers | 524,500 |
| Feeders | 110,000 |
| Crushers | Incl. w/coal handling |
| Deaerator | 29,000 |
| Heaters | Incl. w/boiler |
| Boiler feed pumps | 58,000 |
| Condensate systems | 16,300 |
| Water treating system | 20,000 |
| Chemical feed | 1,500 |
| Compressed air system | 20,000 |
| Coal handling system | 263,900 |
| Ash disposal system | 180,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

Total Equipment Cost \$ 3,946,200

INSTALLATION COSTS, DIRECT

| | |
|---|----------------------------|
| Boiler (including founda- tions and steel) | \$ 1,085,000 |
| Stack | 60,000 |
| Instrumentation | 35,000 |
| Pulverizers | Incl. w/boiler |
| Feeders | Incl. w/boiler |
| Crushers | Incl. w/coal handling |
| Deaerator | 5,000 |
| Heaters | Incl. w/boiler |
| Boiler feed pumps | 8,000 |
| Condensate system | 2,000 |
| Water treating system | 3,500 |
| Chemical feed | 1,500 |
| Coal handling system | 275,000 (incl. site prep.) |
| Ash disposal system | 120,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-51. (continued)

| | |
|--|--------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | 180,000 |
| Duct work (not incl. w/boiler) | N.A. |
| Piping | 80,000 |
| Insulation | 80,000 |
| Painting | 10,000 |
| Electrical | 160,000 |
| Buildings | 380,000 |
| Total Installation Costs | \$ 2,485,000 |
| TOTAL DIRECT COSTS (Equipment + Installation) | \$ 6,431,200 |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ 643,100 |
| Construction and field expense (10% of direct costs) | 643,100 |
| Construction fees (10% of direct costs) | 643,100 |
| Startup (2% of direct costs) | 128,600 |
| Performance tests (minimum \$2000) | 10,000 |
| TOTAL INDIRECT COSTS | \$ 2,067,900 |
| Contingencies (20% of direct and indirect costs) | \$ 1,699,800 |
| Total turnkey costs (Direct + Indirect + Contingencies) | 10,198,900 |
| Land | 2,000 |
| Working capital (25% of total direct operating costs) | 622,300 |
| GRAND TOTAL (Turnkey + Land + Working Capital) | \$10,823,200 |

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-52. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE PULVERIZED-COAL-FIRED BOILER FIRING EASTERN LOW-SULFUR
COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

| | |
|--|-----------------------------|
| DIRECT COST | |
| Direct labor | \$ 421,200 |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>192,200</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>250,000</u> |
| Electricity | <u>237,900</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>3,000</u> |
| Fuel | <u>1,219,400</u> |
| Bottom ash disposal | <u>21,000</u> |
| Chemicals | <u>7,500</u> |
| Total direct cost | <u>\$2,489,100</u> |
| OVERHEAD | |
| Payroll (30% of direct labor) | \$ <u>126,400</u> |
| Plant (26% of labor, parts & maint.) | <u>260,100</u> |
| Total overhead costs | <u>\$ 386,500</u> |
| BYPRODUCT CREDITS | <u>N.A.</u> |
| CAPITAL CHARGES | |
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>408,000</u> |
| Capital recovery factor (10.14% of total turnkey costs) | <u>1,034,200</u> |
| Interest on working capital (10% of working capital) | <u>62,200</u> |
| Total capital charges | <u>\$1,504,400</u> |
| TOTAL ANNUALIZED COSTS | <u>\$4,380,000</u> ✓ |

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-53. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING SUBBITUMINOUS
COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750° F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

| | |
|------------------------------|-----------------------|
| Boiler (with fans and ducts) | \$ 3,067,200 |
| Stack | 365,000 |
| Instrumentation | 228,000 |
| Pulverizers | 754,600 |
| Feeders | 158,400 |
| Crushers | Incl. w/coal handling |
| Deaerator | 29,000 |
| Heaters | Incl. w/boiler |
| Boiler feed pumps | 58,000 |
| Condensate systems | 16,300 |
| Water treating system | 20,000 |
| Chemical feed | 1,500 |
| Compressed air system | 28,800 |
| Coal handling system | 380,000 |
| Ash disposal system | 259,200 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 5,366,000 |

INSTALLATION COSTS, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 1,560,000 |
| Stack | 60,000 |
| Instrumentation | 35,000 |
| Pulverizers | Incl. w/boiler |
| Feeders | Incl. w/boiler |
| Crushers | Incl. w/coal handling |
| Deaerator | 5,000 |
| Heaters | Incl. w/boiler |
| Boiler feed pumps | 8,000 |
| Condensate system | 2,000 |
| Water treating system | 3,500 |
| Chemical feed | 1,500 |
| Coal handling system | 396,000 |
| Ash disposal system | 172,800 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-53. (continued)

| | |
|--|-----------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | 259,200 |
| Duct work (not incl. w/boiler) | N.A. |
| Piping | 115,200 |
| Insulation | 115,200 |
| Painting | 14,400 |
| Electrical | 160,000 |
| Buildings | 547,200 |
| Total Installation Costs | \$ 3,455,000 |
| TOTAL DIRECT COSTS (Equipment + Installation) | \$ 8,821,000 |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ 882,100 |
| Construction and field expense (10% of direct costs) | 882,100 |
| Construction fees (10% of direct costs) | 882,100 |
| Startup (2% of direct costs) | 176,400 |
| Performance tests (minimum \$2000) | 10,000 |
| TOTAL INDIRECT COSTS | \$ 2,832,700 |
| Contingencies (20% of direct and indirect costs) | \$ 2,330,700 |
| Total turnkey costs (Direct + Indirect + Contingencies) | 13,984,400 |
| Land | 2,000 |
| Working capital (25% of total direct operating costs) | 482,000 |
| GRAND TOTAL (Turnkey + Land + Working Capital) | \$ 14,468,400 ✓ |

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-54. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING SUBBITUMINOUS
COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|--------------|
| Direct labor | \$ 421,200 |
| Supervision | 136,900 |
| Maintenance labor | 192,200 |
| Maintenance materials | ^a |
| Replacement parts | 360,000 |
| Electricity | 342,500 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 3,000 |
| Fuel | 441,500 |
| Bottom ash disposal | 23,100 |
| Chemicals | 7,500 |
| Total direct cost | \$1,927,900 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor) | \$ 126,400 |
| Plant (26% of labor, parts & maint.) | 288,700 |
| Total overhead costs | \$ 415,100 |

BYPRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|-------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 559,400 |
| Capital recovery factor (10.14% of total turnkey costs) | 1,418,000 |
| Interest on working capital (10% of working capital) | 48,200 |
| Total capital charges | \$2,025,600 |

| | |
|------------------------|-------------|
| TOTAL ANNUALIZED COSTS | \$4,368,600 |
|------------------------|-------------|

^a Included with replacement parts.

N.A. - Not applicable.

TABLE A-55. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/hr; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 2,224,000 |
| Stack | 365,000 |
| Instrumentation | 228,000 |
| Pulverizers | 548,000 |
| Feeders | 115,000 |
| Crushers | incl. w/coal handling |
| Deaerators | 29,000 |
| Heaters | incl. w/boiler |
| Boiler feed pumps | 58,000 |
| Condensate systems | 16,300 |
| Water treating system | 20,000 |
| Chemical feed | 1,500 |
| Compressed air system | 21,000 |
| Coal handling system | 276,000 |
| Ash disposal system | 188,000 |
| Thawing equipment | incl w/coal handling |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 4,089,800 |

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 1,133,000 |
| Stack | 60,000 |
| Instrumentation | 35,000 |
| Pulverizers | incl. w/boiler |
| Feeders | incl. w/boiler |
| Crushers | incl. w/coal handling |
| Deaerators | 5,000 |
| Heaters | incl. w/boiler |
| Boiler feed pumps | 8,000 |
| Condensate system | 2,000 |
| Water treating system | 3,500 |
| Chemical feed | 1,500 |
| Coal handling system | 287,000 |
| Ash disposal system | 125,000 |
| Thawing equipment | incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-55. (continued)

| INSTALLATION COSTS, DIRECT (cont.) | |
|--|----------------------------|
| Foundations and supports | <u>188,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>84,000</u> |
| Insulation | <u>84,000</u> |
| Painting | <u>10,000</u> |
| Electrical | <u>160,000</u> |
| Buildings | <u>397,000</u> |
| Total installation cost | <u>\$ 2,583,000</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 6,672,800</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 667,300</u> |
| Construction and field expense (10% of direct costs) | <u>667,300</u> |
| Construction fees (10% of direct costs) | <u>667,300</u> |
| Start-up (2% of direct costs) | <u>133,500</u> |
| Performance tests (minimum \$2000) | <u>10,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 2,145,400</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 1,763,600</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>10,581,800</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>577,700</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u><u>\$11,161,500</u></u> |

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-56. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 58.6 MW
(200×10^6 Btu/hr; 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|--------------------|
| Direct labor | <u>\$ 421,200</u> |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>192,200</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>261,000</u> |
| Electricity | <u>248,300</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>3,000</u> |
| Fuel | <u>998,600</u> |
| Bottom ash disposal | <u>42,000</u> |
| Chemicals | <u>7,500</u> |
| Total direct cost | <u>\$2,310,700</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | <u>\$ 126,400</u> |
| Plant (26% of labor, parts & maint.) | <u>262,900</u> |
| Total overhead costs | <u>\$ 389,300</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|--------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | <u>\$ 423,300</u> |
| Capital recovery factor (10.14 % of total turnkey costs) | <u>1,073,000</u> |
| Interest on working capital (10% of working capital) | <u>57,800</u> |
| Total capital charges | <u>\$1,554,100</u> |

TOTAL ANNUALIZED COSTS \$4,254,100

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-57. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
HIGH-SULFUR COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 106 Btu/hr; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|------------------------------|
| Boiler (with fans & ducts) | \$ <u>4,002,300</u> |
| Stack | <u>650,000</u> |
| Instrumentation | <u>378,600</u> |
| Pulverizers | <u>982,800</u> |
| Feeders | <u>209,300</u> |
| Crushers | <u>Incl. w/coal handling</u> |
| Deaerator | <u>60,000</u> |
| Heaters | <u>Incl. w/boiler</u> |
| Boiler feed pumps | <u>150,000</u> |
| Condensate systems | <u>25,000</u> |
| Water treating system | <u>60,000</u> |
| Chemical feed | <u>4,000</u> |
| Compressed air system | <u>46,800</u> |
| Coal handling system | <u>1,170,000</u> |
| Ash disposal system | <u>386,100</u> |
| Thawing equipment | <u>Incl. w/coal handling</u> |
| Fuel-oil system | <u>N.A.</u> |
| Total Equipment Cost | \$ <u>8,124,900</u> |

INSTALLATION COST, DIRECT

| | |
|---|------------------------------|
| Boiler (including founda- tions and steel) | \$ <u>2,538,900</u> |
| Stack | <u>Incl. w/equipment</u> |
| Instrumentation | <u>110,000</u> |
| Pulverizers | <u>Incl. w/boiler</u> |
| Feeders | <u>Incl. w/boiler</u> |
| Crushers | <u>Incl. w/coal handling</u> |
| Deaerator | <u>12,000</u> |
| Heaters | <u>Incl. w/boiler</u> |
| Boiler feed pumps | <u>18,000</u> |
| Condensate system | <u>10,000</u> |
| Water treating system | <u>16,000</u> |
| Chemical feed | <u>2,000</u> |
| Coal handling system | <u>737,100</u> |
| Ash disposal system | <u>304,200</u> |
| Thawing equipment | <u>Incl. w/coal handling</u> |
| Fuel-oil system | <u>N.A.</u> |

N.A. - Not applicable.

TABLE A-57.(continued)

| | |
|---|---------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | 386,000 |
| Duct work (not incl. w/boiler) | N.A. |
| Piping | 146,000 |
| Insulation | 129,000 |
| Painting | 19,000 |
| Electrical | 340,000 |
| Buildings | 761,000 |
| Total installation cost | \$ 5,529,200 |
| TOTAL DIRECT COSTS (equipment + installation) | \$ 13,654,100 |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ 1,365,400 |
| Construction and field expense (10% of direct costs) | 1,365,400 |
| Construction fees (10% of direct costs) | 1,365,400 |
| Startup (2% of direct costs) | 273,100 |
| Performance tests (minimum \$2000) | 15,000 |
| TOTAL INDIRECT COSTS | \$ 4,384,300 |
| Contingencies (20% of direct and indirect costs) | \$ 3,607,700 |
| Total Turnkey Costs (direct+indirect+contingencies) | 21,646,100 |
| Land | 4,000 |
| Working capital (25% of total direct operating costs). | 987,900 |
| GRAND TOTAL (turnkey+land+working capital) | \$ 22,638,000 |

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-58. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
HIGH-SULFUR COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/hr; 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|---------------------|
| Direct labor | \$ 737,100 |
| Supervision | <u>205,400</u> |
| Maintenance labor | <u>384,500</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>409,500</u> |
| Electricity | <u>561,600</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>6,100</u> |
| Fuel | <u>1,555,800</u> |
| Bottom ash disposal | <u>75,500</u> |
| Chemicals | <u>16,000</u> |
| Total direct cost | \$ <u>3,951,500</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor) | \$ <u>221,100</u> |
| Plant (26% of labor, parts & maint.) | <u>451,500</u> |
| Total overhead costs | \$ <u>672,600</u> |

BYPRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|---------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>865,800</u> |
| Capital recovery factor (10.14% of total turnkey costs) | <u>2,194,900</u> |
| Interest on working capital (10% of working capital) | <u>98,800</u> |
| Total capital charges | \$ <u>3,159,500</u> |

| | |
|------------------------|---------------------|
| TOTAL ANNUALIZED COSTS | \$ <u>7,783,600</u> |
|------------------------|---------------------|

^aIncluded in replacement parts.

N.A. - Not Applicable

TABLE A-59. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
LOW-SULFUR COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/hr; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 3,420,800 |
| Stack | 650,000 |
| Instrumentation | 378,600 |
| Pulverizers | 840,000 |
| Feeders | 178,900 |
| Crushers | Incl. w/coal handling |
| Deaerator | 60,000 |
| Heaters | Incl. w/boiler |
| Boiler feed pumps | 150,000 |
| Condensate systems | 25,000 |
| Water treating system | 60,000 |
| Chemical feed | 4,000 |
| Compressed air system | 40,000 |
| Coal handling system | 1,000,000 |
| Ash disposal system | 330,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$ 7,137,300 |

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 2,170,000 |
| Stack | Incl. w/equipment |
| Instrumentation | 110,000 |
| Pulverizers | Incl. w/boiler |
| Feeders | Incl. w/boiler |
| Crushers | Incl. w/coal handling |
| Deaerator | 12,000 |
| Heaters | Incl. w/boiler |
| Boiler feed pumps | 18,000 |
| Condensate system | 10,000 |
| Water treating system | 16,000 |
| Chemical feed | 2,000 |
| Coal handling system | 630,000 |
| Ash disposal system | 260,000 |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-59. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|--------------------------------|----------------|
| Foundations and supports | <u>330,000</u> |
| Duct work (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>125,000</u> |
| Insulation | <u>110,000</u> |
| Painting | <u>16,000</u> |
| Electrical | <u>340,000</u> |
| Buildings | <u>650,000</u> |

Total installation cost \$ 4,799,000

TOTAL DIRECT COSTS

(equipment + installation) \$11,936,300

INSTALLATION COSTS, INDIRECT

| | |
|---|---------------------|
| Engineering (10% of direct costs) | <u>\$ 1,193,600</u> |
| Construction and field expense (10% of direct costs) | <u>1,193,600</u> |
| Construction fees (10% of direct costs) | <u>1,193,600</u> |
| Startup (2% of direct costs) | <u>238,700</u> |
| Performance tests (minimum \$2000) | <u>15,000</u> |

TOTAL INDIRECT COSTS \$ 3,834,500

Contingencies

(20% of direct and indirect costs) \$ 3,154,200

Total Turnkey Costs

(direct+indirect+contingencies) 18,925,000

Land

4,000

Working capital (25% of total direct
operating costs)

1,165,000

GRAND TOTAL

(turnkey+land+working capital) \$20,094,000 ✓

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-60. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
LOW-SULFUR COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/hr; 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|--------------|
| Direct labor | \$ 737,100 |
| Supervision | 205,400 |
| Maintenance labor | 384,500 |
| Maintenance materials | ^a |
| Replacement parts | 350,000 |
| Electricity | 480,000 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 6,100 |
| Fuel | 2,438,800 |
| Bottom ash disposal | 42,000 |
| Chemicals | 16,000 |
| Total direct cost | \$ 4,659,900 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor) | \$ 221,100 |
| Plant (26% of labor, parts & maint.) | 436,000 |
| Total overhead costs | \$ 657,100 |

BYPRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|--------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 757,000 |
| Capital recovery factor (10.14% of total turnkey costs) | 1,919,000 |
| Interest on working capital (10% of working capital) | 116,500 |
| Total capital charges | \$ 2,792,500 |

| | |
|------------------------|--------------|
| TOTAL ANNUALIZED COSTS | \$ 8,109,500 |
|------------------------|--------------|

^aIncluded with replacement parts.

N.A. - Not Applicable

TABLE A-61. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING
SUBBITUMINOUS COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/hr; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ <u>4,926,000</u> |
| Stack | <u>650,000</u> |
| Instrumentation | <u>378,600</u> |
| Pulverizers | <u>1,209,600</u> |
| Feeders | <u>257,600</u> |
| Crushers | Incl. w/coal handling |
| Deaerator | <u>60,000</u> |
| Heaters | Incl. w/boiler |
| Boiler feed pumps | <u>150,000</u> |
| Condensate systems | <u>25,000</u> |
| Water treating system | <u>60,000</u> |
| Chemical feed | <u>4,000</u> |
| Compressed air system | <u>57,600</u> |
| Coal handling system | <u>1,440,000</u> |
| Ash disposal system | <u>475,200</u> |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | <u>N.A.</u> |
| Total Equipment Cost | \$ <u>9,693,600</u> |

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ <u>3,124,800</u> |
| Stack | Incl. w/equipment |
| Instrumentation | <u>110,000</u> |
| Pulverizers | Incl. w/boiler |
| Feeders | Incl. w/boiler |
| Crushers | Incl. w/coal handling |
| Deaerator | <u>12,000</u> |
| Heaters | Incl. w/boiler |
| Boiler feed pumps | <u>18,000</u> |
| Condensate system | <u>10,000</u> |
| Water treating system | <u>16,000</u> |
| Chemical feed | <u>2,000</u> |
| Coal handling system | <u>907,200</u> |
| Ash disposal system | <u>374,400</u> |
| Thawing equipment | Incl. w/coal handling |
| Fuel-oil system | <u>N.A.</u> |

N.A. - Not applicable.

TABLE A-61. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|--------------------------------|----------------|
| Foundations and supports | <u>475,000</u> |
| Duct work (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>180,000</u> |
| Insulation | <u>158,000</u> |
| Painting | <u>23,000</u> |
| Electrical | <u>340,000</u> |
| Buildings | <u>936,000</u> |

| | |
|-------------------------|---------------------|
| Total installation cost | <u>\$ 6,686,400</u> |
|-------------------------|---------------------|

| | |
|--|----------------------|
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 16,380,000</u> |
|--|----------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|---------------------|
| Engineering (10% of direct costs) | <u>\$ 1,638,000</u> |
| Construction and field expense (10% of direct costs) | <u>1,638,000</u> |
| Construction fees (10% of direct costs) | <u>1,638,000</u> |
| Startup (2% of direct costs) | <u>327,600</u> |
| Performance tests (minimum \$2000) | <u>15,000</u> |

| | |
|----------------------|---------------------|
| TOTAL INDIRECT COSTS | <u>\$ 5,256,600</u> |
|----------------------|---------------------|

| | |
|---|---------------------|
| Contingencies (20% of direct and indirect costs) | <u>\$ 4,327,300</u> |
|---|---------------------|

| | |
|--|-------------------|
| Total Turnkey Costs (direct+indirect+contingencies) | <u>25,963,900</u> |
|--|-------------------|

| | |
|------|--------------|
| Land | <u>4,000</u> |
|------|--------------|

| | |
|--|----------------|
| Working capital (25% of total direct operating costs) | <u>868,700</u> |
|--|----------------|

| | |
|---|----------------------|
| GRAND TOTAL (turnkey+land+working capital) | <u>\$ 26,836,600</u> |
|---|----------------------|

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-62. ESTIMATED ANNUALIZED COSTS FOR A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING
SUBBITUMINOUS COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/hr; 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|---------------------|
| Direct labor | \$ <u>737,100</u> |
| Supervision | <u>205,400</u> |
| Maintenance labor | <u>384,500</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>504,000</u> |
| Electricity | <u>691,200</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>6,100</u> |
| Fuel | <u>883,000</u> |
| Bottom ash disposal | <u>47,300</u> |
| Chemicals | <u>16,000</u> |
| Total direct cost | \$ <u>3,474,600</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor) | \$ <u>221,100</u> |
| Plant (26% of labor, parts & maint.) | <u>476,100</u> |
| Total overhead costs | \$ <u>697,200</u> |

BYPRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|---------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>1,038,600</u> |
| Capital recovery factor (10.14% of total turnkey costs) | <u>2,632,700</u> |
| Interest on working capital (10% of working capital) | <u>86,900</u> |
| Total capital charges | \$ <u>3,758,200</u> |

| | |
|------------------------|---------------------|
| TOTAL ANNUALIZED COSTS | \$ <u>7,930,000</u> |
|------------------------|---------------------|

^aIncluded in replacement parts.

N.A. - Not Applicable

TABLE A-63. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/hr; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|------------------------------|
| Boiler (with fans & ducts) | \$ 3,571,300 |
| Stack | <u>650,000</u> |
| Instrumentation | <u>378,600</u> |
| Pulverizers | <u>877,000</u> |
| Feeders | <u>186,800</u> |
| Crushers | <u>Incl. w/coal handling</u> |
| Deaerator | <u>60,000</u> |
| Heaters | <u>Incl. w/boiler</u> |
| Boiler feed pumps | <u>150,000</u> |
| Condensate systems | <u>25,000</u> |
| Water treating system | <u>60,000</u> |
| Chemical feed | <u>4,000</u> |
| Compressed air system | <u>41,800</u> |
| Coal handling system | <u>1,044,000</u> |
| Ash disposal system | <u>344,500</u> |
| Thawing equipment | <u>Incl. w/coal handling</u> |
| Fuel-oil system | <u>N.A.</u> |
| Total Equipment Cost | \$ 7,393,000 |

INSTALLATION COST, DIRECT

| | |
|---|------------------------------|
| Boiler (including founda- tions and steel) | \$ 2,265,500 |
| Stack | <u>Incl. w/equipment</u> |
| Instrumentation | <u>110,000</u> |
| Pulverizers | <u>Incl. w/boiler</u> |
| Feeders | <u>Incl. w/boiler</u> |
| Crushers | <u>Incl. w/coal handling</u> |
| Deaerator | <u>12,000</u> |
| Heaters | <u>Incl. w/boiler</u> |
| Boiler feed pumps | <u>18,000</u> |
| Condensate system | <u>10,000</u> |
| Water treating system | <u>16,000</u> |
| Chemical feed | <u>2,000</u> |
| Coal handling system | <u>657,700</u> |
| Ash disposal system | <u>271,400</u> |
| Thawing equipment | <u>Incl. w/coal handling</u> |
| Fuel-oil system | <u>N.A.</u> |

N.A. - Not applicable.

TABLE A-63.(continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|--------------------------------|----------------|
| Foundations and supports | <u>344,500</u> |
| Duct work (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>130,500</u> |
| Insulation | <u>114,800</u> |
| Painting | <u>16,700</u> |
| Electrical | <u>340,000</u> |
| Buildings | <u>678,600</u> |

Total installation cost \$ 4,987,700

TOTAL DIRECT COSTS
(equipment + installation) \$ 12,380,700

INSTALLATION COSTS, INDIRECT

| | |
|---|---------------------|
| Engineering (10% of direct costs) | \$ <u>1,238,100</u> |
| Construction and field expense (10% of direct costs) | <u>1,238,100</u> |
| Construction fees (10% of direct costs) | <u>1,238,100</u> |
| Startup (2% of direct costs) | <u>247,600</u> |
| Performance tests (minimum \$2000) | <u>15,000</u> |

TOTAL INDIRECT COSTS \$ 3,976,900

Contingencies
(20% of direct and indirect costs) \$ 3,271,500

Total Turnkey Costs
(direct+indirect+contingencies) 19,629,100

Land 4,000

Working capital (25% of total direct
operating costs) 1,074,200

GRAND TOTAL
(turnkey+land+working capital) \$ 20,707,300

^a Quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-64. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/hr; 750 psig/750°F design)

| | |
|--|---------------------|
| DIRECT COST | |
| Direct labor | \$ 737,100 |
| Supervision | 205,400 |
| Maintenance labor | 384,500 |
| Maintenance materials | a |
| Replacement parts | 365,400 |
| Electricity | 501,100 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 6,100 |
| Fuel | 1,997,000 |
| Bottom ash disposal | 84,000 |
| Chemicals | 16,000 |
| Total direct cost | \$ 4,296,600 |
| OVERHEAD | |
| Payroll (30% of direct labor) | \$ 221,100 |
| Plant (26% of labor, parts & maint.) | 440,000 |
| Total overhead costs | \$ 661,100 |
| BYPRODUCT CREDITS | N.A. |
| CAPITAL CHARGES | |
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 785,200 |
| Capital recovery factor (10.14% of total turnkey costs) | 1,990,400 |
| Interest on working capital (10% of working capital) | 107,400 |
| Total capital charges | \$ 2,883,000 |
| TOTAL ANNUALIZED COSTS | \$ 7,840,700 |

^a Included with replacement parts.
N.A. - Not applicable.

TABLE A-65. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
HIGH-SULFUR COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 6,487,000 |
| Stack | 1,250,000 |
| Instrumentation | 610,800 |
| Pulverizers | 1,625,000 |
| Feeders | 334,000 |
| Crushers | incl. w/coal handling |
| Deaerators | 85,000 |
| Heaters | incl. w/boiler |
| Boiler feed pumps | 195,000 |
| Condensate systems | 35,000 |
| Water treating system | 90,000 |
| Chemical feed | 4,000 |
| Compressed air system | 60,000 |
| Coal handling system | 1,747,000 |
| Ash disposal system | 819,000 |
| Thawing equipment | incl. w/coal handling |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$13,341,800 |

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 3,604,000 |
| Stack | incl. w/equipment |
| Instrumentation | 160,000 |
| Pulverizers | incl. w/boiler |
| Feeders | incl. w/boiler |
| Crushers | incl. w/coal handling |
| Deaerators | 19,000 |
| Heaters | incl. w/boiler |
| Boiler feed pumps | 25,000 |
| Condensate system | 16,000 |
| Water treating system | 28,000 |
| Chemical feed | 2,000 |
| Coal handling system | 1,092,000 |
| Ash disposal system | 546,000 |
| Thawing equipment | incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-65. (continued)

| <hr/> <hr/> INSTALLATION COSTS, DIRECT (cont.) | |
|--|-----------------------|
| Foundations and supports | <u>710,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>262,000</u> |
| Insulation | <u>208,000</u> |
| Painting | <u>32,000</u> |
| Electrical | <u>650,000</u> |
| Buildings | <u>1,365,000</u> |
| Total installation cost | <u>\$ 8,719,000</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$22,060,800</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 2,206,100</u> |
| Construction and field expense (10% of direct costs) | <u>2,206,100</u> |
| Construction fees (10% of direct costs) | <u>2,206,100</u> |
| Start-up (2% of direct costs) | <u>441,200</u> |
| Performance tests (minimum \$2000) | <u>25,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 7,084,500</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 5,829,100</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>34,974,400</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>1,513,800</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u>\$36,490,200 -</u> |

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-66. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
HIGH-SULFUR COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

DIRECT COST

| | |
|-----------------------|---------------------|
| Direct labor | <u>\$ 1,000,300</u> |
| Supervision | <u>205,400</u> |
| Maintenance labor | <u>512,600</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>463,300</u> |
| Electricity | <u>983,000</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>10,600</u> |
| Fuel | <u>2,722,600</u> |
| Bottom ash disposal | <u>132,500</u> |
| Chemicals | <u>25,000</u> |
| Total direct cost | <u>\$ 6,055,300</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | <u>\$ 300,100</u> |
| Plant (26% of labor, parts & maint.) | <u>567,200</u> |
| Total overhead costs | <u>\$ 867,300</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|---------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | <u>\$ 1,399,000</u> |
| Capital recovery factor (10.14 % of total turnkey costs) | <u>3,546,400</u> |
| Interest on working capital (10% of working capital) | <u>151,400</u> |
| Total capital charges | <u>\$ 5,096,800</u> |

TOTAL ANNUALIZED COSTS \$12,019,400 ✓

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-67. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
LOW-SULFUR COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 5,524,000 |
| Stack | 1,250,000 |
| Instrumentation | 610,800 |
| Pulverizers | 1,384,000 |
| Feeders | 284,000 |
| Crushers | incl. w/coal handling |
| Deaerators | 85,000 |
| Heaters | incl. w/boiler |
| Boiler feed pumps | 195,000 |
| Condensate systems | 35,000 |
| Water treating system | 90,000 |
| Chemical feed | 4,000 |
| Compressed air system | 51,000 |
| Coal handling system | 1,488,000 |
| Ash disposal system | 698,000 |
| Thawing equipment | incl. w/coal handling |
| Fuel-oil system | N.A. |

Total Equipment Cost \$11,698,800

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 3,069,000 |
| Stack | incl. w/equipment |
| Instrumentation | 160,000 |
| Pulverizers | incl. w/boiler |
| Feeders | incl. w/boiler |
| Crushers | incl. w/coal handling |
| Deaerators | 19,000 |
| Heaters | incl. w/boiler |
| Boiler feed pumps | 25,000 |
| Condensate system | 16,000 |
| Water treating system | 28,000 |
| Chemical feed | 2,000 |
| Coal handling system | 930,000 |
| Ash disposal system | 465,000 |
| Thawing equipment | incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-67. (continued)

| | |
|---|----------------------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | <u>605,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>223,000</u> |
| Insulation | <u>177,000</u> |
| Painting | <u>27,000</u> |
| Electrical | <u>650,000</u> |
| Buildings | <u>1,163,000</u> |
| Total installation cost | <u>\$ 7,559,000</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$19,257,800</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 1,925,800</u> |
| Construction and field expense (10% of direct costs) | <u>1,925,800</u> |
| Construction fees (10% of direct costs) | <u>1,925,800</u> |
| Start-up (2% of direct costs) | <u>385,200</u> |
| Performance tests (minimum \$2000) | <u>25,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 6,187,600</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 5,089,100</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>30,534,500</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>1,832,700</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u><u>\$32,369,200</u></u> |

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-68. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
LOW-SULFUR COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

DIRECT COST

| | |
|-----------------------|---------------------|
| Direct labor | <u>\$ 1,000,300</u> |
| Supervision | <u>205,400</u> |
| Maintenance labor | <u>512,600</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>395,300</u> |
| Electricity | <u>840,100</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>10,600</u> |
| Fuel | <u>4,267,900</u> |
| Bottom ash disposal | <u>73,600</u> |
| Chemicals | <u>25,000</u> |
| Total direct cost | <u>\$ 7,330,800</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor) | <u>\$ 300,100</u> |
| Plant (26% of labor, parts & maint.) | <u>549,500</u> |
| Total overhead costs | <u>\$ 849,600</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|---------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | <u>\$ 1,221,400</u> |
| Capital recovery factor (10.14 % of total turnkey costs) | <u>3,096,200</u> |
| Interest on working capital (10% of working capital) | <u>183,300</u> |
| Total capital charges | <u>\$ 4,500,900</u> |

| | |
|------------------------|---------------------|
| TOTAL ANNUALIZED COSTS | <u>\$12,681,300</u> |
|------------------------|---------------------|

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-69. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING SUBBITUMINOUS
COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 7,960,000 |
| Stack | 1,250,000 |
| Instrumentation | 610,800 |
| Pulverizers | 1,994,000 |
| Feeders | 409,000 |
| Crushers | incl. w/coal handling |
| Deaerators | 85,000 |
| Heaters | incl. w/boiler |
| Boiler feed pumps | 195,000 |
| Condensate systems | 35,000 |
| Water treating system | 90,000 |
| Chemical feed | 4,000 |
| Compressed air system | 74,000 |
| Coal handling system | 2,144,000 |
| Ash disposal system | 1,005,000 |
| Thawing equipment | incl. w/coal handling |
| Fuel-oil system | N.A. |
| Total Equipment Cost | \$15,855,800 |

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 4,422,000 |
| Stack | incl. w/equipment |
| Instrumentation | 160,000 |
| Pulverizers | incl. w/boiler |
| Feeders | incl. w/boiler |
| Crushers | incl. w/coal handling |
| Deaerators | 19,000 |
| Heaters | incl. w/boiler |
| Boiler feed pumps | 25,000 |
| Condensate system | 16,000 |
| Water treating system | 28,000 |
| Chemical feed | 2,000 |
| Coal handling system | 1,340,000 |
| Ash disposal system | 670,000 |
| Thawing equipment | incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-69. (continued)

| | |
|---|---------------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | <u>871,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>322,000</u> |
| Insulation | <u>255,000</u> |
| Painting | <u>39,000</u> |
| Electrical | <u>650,000</u> |
| Buildings | <u>1,675,000</u> |
| Total installation cost | <u>\$10,494,000</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$26,349,800</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 2,635,000</u> |
| Construction and field expense (10% of direct costs) | <u>2,635,000</u> |
| Construction fees (10% of direct costs) | <u>2,635,000</u> |
| Start-up (2% of direct costs) | <u>527,000</u> |
| Performance tests (minimum \$2000) | <u>25,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 8,457,000</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 6,961,400</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>41,768,200</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>1,290,100</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u>\$43,060,300</u> |

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-70. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING SUBBITUMINOUS
COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

DIRECT COST

| | |
|-----------------------|---------------------|
| Direct labor | \$ 1,000,300 |
| Supervision | <u>205,400</u> |
| Maintenance labor | <u>512,600</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>569,500</u> |
| Electricity | <u>1,209,600</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>10,600</u> |
| Fuel | <u>1,545,300</u> |
| Bottom ash disposal | <u>82,000</u> |
| Chemicals | <u>25,000</u> |
| Total direct cost | <u>\$ 5,160,300</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | \$ <u>300,100</u> |
| Plant (26% of labor, parts & maint.) | <u>594,800</u> |
| Total overhead costs | <u>\$ 894,900</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|---------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>1,670,700</u> |
| Capital recovery factor (10,14 % of total turnkey costs) | <u>4,235,300</u> |
| Interest on working capital (10% of working capital) | <u>129,000</u> |
| Total capital charges | <u>\$ 6,035,000</u> |

TOTAL ANNUALIZED COSTS \$12,090,200

a Included with replacement parts.

N.A. - Not applicable.

TABLE A-71. ESTIMATED CAPITAL COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-----------------------|
| Boiler (with fans & ducts) | \$ 5,762,000 |
| Stack | 1,250,000 |
| Instrumentation | 610,800 |
| Pulverizers | 1,443,000 |
| Feeders | 296,000 |
| Crushers | incl. w/coal handling |
| Deaerators | 85,000 |
| Heaters | incl. w/boiler |
| Boiler feed pumps | 195,000 |
| Condensate systems | 35,000 |
| Water treating system | 90,000 |
| Chemical feed | 4,000 |
| Compressed air system | 53,000 |
| Coal handling system | 1,552,000 |
| Ash disposal system | 728,000 |
| Thawing equipment | incl. w/coal handling |
| Fuel-oil system | N.A. |

Total Equipment Cost \$12,103,800

INSTALLATION COST, DIRECT

| | |
|---|-----------------------|
| Boiler (including founda- tions and steel) | \$ 3,201,000 |
| Stack | incl. w/equipment |
| Instrumentation | 160,000 |
| Pulverizers | incl. w/boiler |
| Feeders | incl. w/boiler |
| Crushers | incl. w/coal handling |
| Deaerators | 19,000 |
| Heaters | incl. w/boiler |
| Boiler feed pumps | 25,000 |
| Condensate system | 16,000 |
| Water treating system | 28,000 |
| Chemical feed | 2,000 |
| Coal handling system | 970,000 |
| Ash disposal system | 485,000 |
| Thawing equipment | incl. w/coal handling |
| Fuel-oil system | N.A. |

N.A. - Not applicable.

TABLE A-71. (continued)

| | |
|---|---------------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | <u>631,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>233,000</u> |
| Insulation | <u>184,000</u> |
| Painting | <u>28,000</u> |
| Electrical | <u>650,000</u> |
| Buildings | <u>1,213,000</u> |
| Total installation cost | <u>\$ 7,845,000</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$19,948,800</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 1,994,900</u> |
| Construction and field expense (10% of direct costs) | <u>1,994,900</u> |
| Construction fees (10% of direct costs) | <u>1,994,900</u> |
| Start-up (2% of direct costs) | <u>399,000</u> |
| Performance tests (minimum \$2000) | <u>25,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 6,408,700</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 5,271,500</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>31,629,000</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>1,671,400</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u>\$33,302,400</u> |

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE A-72. ESTIMATED ANNUALIZED COSTS OF A FIELD-ERECTED,
WATER-TUBE, PULVERIZED-COAL-FIRED BOILER FIRING EASTERN
MEDIUM-SULFUR COAL WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/hr; 900 psig/750°F design)

DIRECT COST

| | |
|-----------------------|---------------------|
| Direct labor | \$ 1,000,300 |
| Supervision | <u>205,400</u> |
| Maintenance labor | <u>512,600</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>412,300</u> |
| Electricity | <u>876,800</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>10,600</u> |
| Fuel | <u>3,495,200</u> |
| Bottom ash disposal | <u>147,200</u> |
| Chemicals | <u>25,000</u> |
| Total direct cost | <u>\$ 6,685,400</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | \$ <u>300,100</u> |
| Plant (26% of labor, parts & maint.) | <u>554,000</u> |
| Total overhead costs | <u>\$ 854,100</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|---------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>1,265,200</u> |
| Capital recovery factor (10.14% of total turnkey costs) | <u>3,207,200</u> |
| Interest on working capital (10% of working capital) | <u>167,100</u> |
| Total capital charges | <u>\$ 4,639,500</u> |

TOTAL ANNUALIZED COSTS \$12,179,000 -

a Included with replacement parts.

N.A. - Not applicable.

APPENDIX B

DETAILED CAPITAL AND ANNUALIZED COST TABLES
FOR PACKAGE, FIRE-TUBE BOILERS FIRED BY
RESIDUAL OIL, DISTILLATE OIL, AND
NATURAL GAS

TABLE B-1. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING RESIDUAL OIL WITH A THERMAL INPUT OF 1.5 MW
(5 x 10⁶ Btu/h; 125 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|--------------------|
| Boiler (with fans & ducts) | \$ 19,100 |
| Stack | 2,000 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | Incl. w/condensate |
| Heaters | N.A. |
| Boiler feed pumps | 3,500 |
| Condensate systems | 4,000 |
| Water treating system | 1,200 |
| Chemical feed | Incl. w/boiler |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 13,000 |
| Total Equipment Cost | \$ 42,800 |

INSTALLATION COST, DIRECT

| | |
|---|-----------------|
| Boiler (including founda- tions and steel) | \$ 3,000 |
| Stack | 1,000 |
| Instrumentation | Incl. w/ boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | N.A. |
| Heaters | N.A. |
| Boiler feed pumps | 800 |
| Condensate system | 800 |
| Water treating system | 1,000 |
| Chemical feed | 200 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 3,000 |

N.A. - Not applicable.

TABLE B-1. (continued)

| | |
|---|--------------------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | <u>2,500</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>12,000</u> |
| Insulation | <u>8,000</u> |
| Painting | <u>2,500</u> |
| Electrical | <u>10,000</u> |
| Buildings | <u>35,000</u> |
| Total installation cost | <u>\$ 79,800</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 122,600</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 12,300</u> |
| Construction and field expense (10% of direct costs) | <u>12,300</u> |
| Construction fees (10% of direct costs) | <u>12,300</u> |
| Start-up (2% of direct costs) | <u>2,500</u> |
| Performance tests (minimum \$2000) | <u>2,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 41,400</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 32,800</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>196,800</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>44,900</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u><u>\$ 243,700</u></u> |

^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-2. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING RESIDUAL OIL WITH A THERMAL INPUT OF 1.5 MW
(5 x 10⁶ Btu/h; 125 hp; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|------------|
| Direct labor | \$ 105,300 |
| Supervision | 0 |
| Maintenance labor | 16,000 |
| Maintenance materials | a |
| Replacement parts | 8,000 |
| Electricity | 6,000 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 100 |
| Fuel | 43,600 |
| Bottom ash disposal | N.A. |
| Chemicals | 700 |
| Total direct cost | \$ 179,700 |

OVERHEAD

| | |
|--------------------------------------|-----------|
| Payroll (30% of direct labor) | \$ 31,600 |
| Plant (26% of labor, parts & maint.) | 33,600 |
| Total overhead costs | \$ 65,200 |

| | |
|--------------------|------|
| BY-PRODUCT CREDITS | N.A. |
|--------------------|------|

CAPITAL CHARGES

| | |
|---|-----------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 7,900 |
| Capital recovery factor (11.75 % of total turnkey costs) | 23,100 |
| Interest on working capital (10% of working capital) | 4,500 |
| Total capital charges | \$ 35,500 |

| | |
|------------------------|------------|
| TOTAL ANNUALIZED COSTS | \$ 280,400 |
|------------------------|------------|

a Included with replacement parts.

N.A. - Not applicable.

TABLE B-3. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE BOILER FIRING RESIDUAL OIL WITH A THERMAL INPUT OF 4.4 MW (15 x 10⁶ Btu/h; 300 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|----------------|
| Boiler (with fans & ducts) | \$ 36,100 |
| Stack | 2,700 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 4,000 |
| Heaters | N.A. |
| Boiler feed pumps | 6,100 |
| Condensate systems | 5,000 |
| Water treating system | 1,400 |
| Chemical feed | Incl. w/boiler |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 22,000 |

Total Equipment Cost \$ 77,300

INSTALLATION COST, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 5,000 |
| Stack | 1,500 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 1,500 |
| Heaters | N.A. |
| Boiler feed pumps | 1,200 |
| Condensate system | 1,000 |
| Water treating system | 1,500 |
| Chemical feed | 400 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 4,000 |

N.A. - Not applicable.

TABLE B-3. (continued)

| | |
|---|------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | 3,500 |
| Ductwork (not incl. w/boiler) | N.A. |
| Piping | 20,000 |
| Insulation | 10,000 |
| Painting | 3,000 |
| Electrical | 15,000 |
| Buildings | 50,000 |
| Total installation cost | \$ 117,600 |
| TOTAL DIRECT COSTS (equipment + installation) | \$ 194,900 |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ 19,500 |
| Construction and field expense (10% of direct costs) | 19,500 |
| Construction fees (10% of direct costs) | 19,500 |
| Start-up (2% of direct costs) | 3,900 |
| Performance tests (minimum \$2000) | 2,000 |
| TOTAL INDIRECT COSTS | \$ 64,400 |
| Contingencies (20% of direct and indirect costs) | \$ 51,900 |
| Total Turnkey Costs (direct+indirect+contingencies) | 311,200 |
| Land | 2,000 |
| Working capital (25% of total direct operating costs) | 91,000 |
| GRAND TOTAL (turnkey+land+working capital) | \$ 404,200 |

^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-4. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING RESIDUAL OIL WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 300 hp; 150 psig/sat. temp design)

DIRECT COST

| | |
|-----------------------|-------------------|
| Direct labor | \$ <u>105,300</u> |
| Supervision | <u>68,500</u> |
| Maintenance labor | <u>32,000</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>15,000</u> |
| Electricity | <u>11,600</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>200</u> |
| Fuel | <u>130,700</u> |
| Bottom ash disposal | <u>N.A.</u> |
| Chemicals | <u>800</u> |
| Total direct cost | \$ <u>364,100</u> |

OVERHEAD

| | |
|--------------------------------------|------------------|
| Payroll (30% of direct labor) | \$ <u>31,600</u> |
| Plant (26% of labor, parts & maint.) | <u>57,400</u> |
| Total overhead costs | \$ <u>89,000</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>12,400</u> |
| Capital recovery factor (11.75 % of total turnkey costs) | <u>36,600</u> |
| Interest on working capital (10% of working capital) | <u>9,100</u> |
| Total capital charges | \$ <u>58,100</u> |

| | |
|------------------------|-------------------|
| TOTAL ANNUALIZED COSTS | \$ <u>511,200</u> |
|------------------------|-------------------|

a Included with replacement parts.

N.A. - Not applicable.

TABLE B-5. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE BOILER FIRING RESIDUAL OIL WITH A THERMAL INPUT OF 8.5 MW (29 x 10⁶ Btu/h; 700 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|----------------|
| Boiler (with fans & ducts) | \$ 51,000 |
| Stack | 4,000 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 5,000 |
| Heaters | N.A. |
| Boiler feed pumps | 13,000 |
| Condensate systems | 6,000 |
| Water treating system | 2,000 |
| Chemical feed | 1,400 |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 32,000 |

Total Equipment Cost

\$ 114,400

INSTALLATION COST, DIRECT

| | |
|--|----------------|
| Boiler (including foundations and steel) | \$ 9,000 |
| Stack | 2,000 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 2,500 |
| Heaters | N.A. |
| Boiler feed pumps | 3,000 |
| Condensate system | 1,000 |
| Water treating system | 2,000 |
| Chemical feed | 1,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 8,000 |

N.A. - Not applicable.

TABLE B-5. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|---------------|
| Foundations and supports | <u>15,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>25,000</u> |
| Insulation | <u>20,000</u> |
| Painting | <u>4,000</u> |
| Electrical | <u>20,000</u> |
| Buildings | <u>70,000</u> |

| | |
|-------------------------|-------------------|
| Total installation cost | <u>\$ 183,000</u> |
|-------------------------|-------------------|

TOTAL DIRECT COSTS

| | |
|----------------------------|-------------------|
| (equipment + installation) | <u>\$ 297,400</u> |
|----------------------------|-------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|------------------|
| Engineering (10% of direct costs) | <u>\$ 29,700</u> |
| Construction and field expense (10% of direct costs) | <u>29,700</u> |
| Construction fees (10% of direct costs) | <u>29,700</u> |
| Start-up (2% of direct costs) | <u>5,900</u> |
| Performance tests (minimum \$2000) | <u>2,000</u> |

| | |
|----------------------|------------------|
| TOTAL INDIRECT COSTS | <u>\$ 97,000</u> |
|----------------------|------------------|

Contingencies

| | |
|------------------------------------|------------------|
| (20% of direct and indirect costs) | <u>\$ 78,900</u> |
|------------------------------------|------------------|

Total Turnkey Costs

| | |
|---------------------------------|----------------|
| (direct+indirect+contingencies) | <u>473,300</u> |
|---------------------------------|----------------|

Land

| |
|--------------|
| <u>2,000</u> |
|--------------|

| | |
|--|----------------|
| Working capital (25% of total direct operating costs) | <u>127,200</u> |
|--|----------------|

GRAND TOTAL

| | |
|--------------------------------|-------------------|
| (turnkey+land+working capital) | <u>\$ 602,500</u> |
|--------------------------------|-------------------|

^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-6. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING RESIDUAL OIL WITH A THERMAL INPUT OF 8.5 MW
(29 x 10⁶ Btu/h; 700 hp; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|------------|
| Direct labor | \$ 105,300 |
| Supervision | 68,500 |
| Maintenance labor | 32,000 |
| Maintenance materials | a |
| Replacement parts | 25,000 |
| Electricity | 24,000 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 400 |
| Fuel | 252,600 |
| Bottom ash disposal | N.A. |
| Chemicals | 1,000 |
| Total direct cost | \$ 508,800 |

OVERHEAD

| | |
|--------------------------------------|-----------|
| Payroll (30% of direct labor) | \$ 31,600 |
| Plant (26% of labor, parts & maint.) | 60,000 |
| Total overhead costs | \$ 91,600 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|-----------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 18,900 |
| Capital recovery factor (11.75 % of total turnkey costs) | 55,600 |
| Interest on working capital (10% of working capital) | 12,700 |
| Total capital charges | \$ 87,200 |

TOTAL ANNUALIZED COSTS \$ 687,600 ✓

a Included with replacement parts.
N.A. - Not applicable.

TABLE B-7. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING DISTILLATE OIL WITH A
THERMAL INPUT OF 1.5 MW
(5×10^6 Btu/h; 125 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

| | |
|----------------------------|--------------------|
| Boiler (with fans & ducts) | \$ 19,100 |
| Stack | 2,000 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | Incl. w/condensate |
| Heaters | N.A. |
| Boiler feed pumps | 3,500 |
| Condensate systems | 4,000 |
| Water treating system | 1,200 |
| Chemical feed | Incl. w/boiler |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 10,000 |

Total Equipment Cost \$ 39,800

INSTALLATION COST, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 3,000 |
| Stack | 1,000 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | N.A. |
| Heaters | N.A. |
| Boiler feed pumps | 800 |
| Condensate system | 800 |
| Water treating system | 1,000 |
| Chemical feed | 200 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 2,500 |

N.A. - Not applicable.

TABLE B-7. (continued)

| <u>INSTALLATION COSTS, DIRECT (cont.)</u> | |
|--|-------------------|
| Foundations and supports | <u>2,500</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>12,000</u> |
| Insulation | <u>8,000</u> |
| Painting | <u>2,500</u> |
| Electrical | <u>10,000</u> |
| Buildings | <u>35,000</u> |
| Total installation cost | <u>\$ 79,300</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 119,100</u> |
| <u>INSTALLATION COSTS, INDIRECT</u> | |
| Engineering (10% of direct costs) | <u>\$ 11,900</u> |
| Construction and field expense (10% of direct costs) | <u>11,900</u> |
| Construction fees (10% of direct costs) | <u>11,900</u> |
| Start-up (2% of direct costs) | <u>2,400</u> |
| Performance tests (minimum \$2000) | <u>2,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 40,100</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 31,800</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>191,000</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>48,800</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u>\$ 241,800</u> |

^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-8. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING DISTILLATE OIL WITH A THERMAL INPUT OF 1.5 MW
(5 x 10⁶ Btu/h; 125 hp; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|------------|
| Direct labor | \$ 105,300 |
| Supervision | 0 |
| Maintenance labor | 16,000 |
| Maintenance materials | a |
| Replacement parts | 8,000 |
| Electricity | 6,000 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 100 |
| Fuel | 59,100 |
| Bottom ash disposal | N.A. |
| Chemicals | 700 |
| Total direct cost | \$ 195,200 |

OVERHEAD

| | |
|--------------------------------------|-----------|
| Payroll (30% of direct labor) | \$ 31,600 |
| Plant (26% of labor, parts & maint.) | 33,600 |
| Total overhead costs | \$ 65,200 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|-----------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 7,600 |
| Capital recovery factor (11.75 % of total turnkey costs) | 22,400 |
| Interest on working capital (10% of working capital) | 4,900 |
| Total capital charges | \$ 34,900 |

| | |
|------------------------|------------|
| TOTAL ANNUALIZED COSTS | \$ 295,300 |
|------------------------|------------|

a Included with replacement parts.

N.A. - Not applicable.

TABLE B-9. ESTIMATED CAPITAL COSTS OF A PACKAGE FIRE-TUBE BOILER FIRING DISTILLATE OIL WITH A THERMAL INPUT OF 4.4 MW (15 x 10⁶ Btu/h; 300 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|-----------------------------|----------------|
| Boiler (with fans and duct) | \$ 36,100 |
| Stack | 2,700 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerator | 4,000 |
| Heaters | N.A. |
| Boiler feed pumps | 6,100 |
| Condensate systems | 5,000 |
| Water treating system | 1,400 |
| Chemical feed | Incl. w/boiler |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 16,000 |
| Total Equipment Cost | \$ 71,300 |

INSTALLATION COSTS, DIRECT

| | |
|--|----------------|
| Boiler (including foundations and steel) | \$ 5,000 |
| Stack | 1,500 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerator | 1,500 |
| Heaters | N.A. |
| Boiler feed pumps | 1,200 |
| Condensate system | 1,000 |
| Water treating system | 1,500 |
| Chemical feed | 400 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 3,000 |

N.A. - Not applicable.

TABLE B-9. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|--------------------------------|---------------|
| Foundations and supports | <u>3,500</u> |
| Duct work (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>20,000</u> |
| Insulation | <u>10,000</u> |
| Painting | <u>3,000</u> |
| Electrical | <u>15,000</u> |
| Buildings | <u>50,000</u> |

| | |
|--------------------------|-------------------|
| Total Installation Costs | <u>\$ 116,600</u> |
|--------------------------|-------------------|

| | |
|--|-------------------|
| TOTAL DIRECT COSTS (Equipment + Installation) | <u>\$ 187,900</u> |
|--|-------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|------------------|
| Engineering (10% of direct costs) | <u>\$ 18,800</u> |
| Construction and field expense (10% of direct costs) | <u>18,800</u> |
| Construction fees (10% of direct costs) | <u>18,800</u> |
| Startup (2% of direct costs) | <u>3,800</u> |
| Performance tests (minimum \$2000) | <u>2,000</u> |

| | |
|----------------------|------------------|
| TOTAL INDIRECT COSTS | <u>\$ 62,200</u> |
|----------------------|------------------|

| | |
|---|------------------|
| Contingencies (20% of direct and indirect costs) | <u>\$ 50,000</u> |
|---|------------------|

| | |
|--|----------------|
| Total turnkey costs (Direct + Indirect + Contingencies) | <u>300,100</u> |
|--|----------------|

| | |
|------|--------------|
| Land | <u>2,000</u> |
|------|--------------|

| | |
|--|----------------|
| Working capital (25% of total direct operating costs) | <u>102,700</u> |
|--|----------------|

| | |
|---|--------------------------|
| GRAND TOTAL (Turnkey + Land + Working Capital) | <u><u>\$ 404,800</u></u> |
|---|--------------------------|

^a Quote from Cleaver-Brooks, May 11, 1978.
N.A. - Not applicable.

TABLE B-10. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING DISTILLATE OIL WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 300 hp; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|------------|
| Direct labor | \$ 105,300 |
| Supervision | 68,500 |
| Maintenance labor | 32,000 |
| Maintenance materials | a |
| Replacement parts | 15,000 |
| Electricity | 11,600 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 200 |
| Fuel | 177,400 |
| Bottom ash disposal | N.A. |
| Chemicals | 800 |
| Total direct cost | \$ 410,800 |

OVERHEAD

| | |
|--------------------------------------|-----------|
| Payroll (30% of direct labor) | \$ 31,600 |
| Plant (26% of labor, parts & maint.) | 57,400 |
| Total overhead costs | \$ 89,000 |

BYPRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|-----------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 12,000 |
| Capital recovery factor (11.75% of total turnkey costs) | 35,300 |
| Interest on working capital (10% of working capital) | 10,300 |
| Total capital charges | \$ 57,600 |

TOTAL ANNUALIZED COSTS

\$ 557,400

^a Included with replacement parts.

N.A. - Not applicable.

TABLE B-11. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE BOILER FIRING DISTILLATE OIL WITH A THERMAL INPUT OF 8.5 MW (29 x 10⁶ Btu/h; 700 hp; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|----------------|
| Boiler (with fans & ducts) | \$ 51,000 |
| Stack | 4,000 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 5,000 |
| Heaters | N.A. |
| Boiler feed pumps | 13,000 |
| Condensate systems | 6,000 |
| Water treating system | 2,000 |
| Chemical feed | 1,400 |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 25,000 |
| Total Equipment Cost | \$ 107,400 |

INSTALLATION COST, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 9,000 |
| Stack | 2,000 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 2,500 |
| Heaters | N.A. |
| Boiler feed pumps | 3,000 |
| Condensate system | 1,000 |
| Water treating system | 2,000 |
| Chemical feed | 1,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 6,000 |

N.A. - Not applicable.

TABLE B-11. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|---------------|
| Foundations and supports | <u>15,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>25,000</u> |
| Insulation | <u>20,000</u> |
| Painting | <u>4,000</u> |
| Electrical | <u>20,000</u> |
| Buildings | <u>70,000</u> |

| | |
|-------------------------|------------------|
| Total installation cost | <u>\$181,000</u> |
|-------------------------|------------------|

TOTAL DIRECT COSTS

| | |
|----------------------------|------------------|
| (equipment + installation) | <u>\$288,400</u> |
|----------------------------|------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|------------------|
| Engineering (10% of direct costs) | <u>\$ 28,800</u> |
| Construction and field expense (10% of direct costs) | <u>28,800</u> |
| Construction fees (10% of direct costs) | <u>28,800</u> |
| Start-up (2% of direct costs) | <u>5,800</u> |
| Performance tests (minimum \$2000) | <u>2,000</u> |

| | |
|----------------------|------------------|
| TOTAL INDIRECT COSTS | <u>\$ 94,200</u> |
|----------------------|------------------|

Contingencies

| | |
|------------------------------------|------------------|
| (20% of direct and indirect costs) | <u>\$ 76,500</u> |
|------------------------------------|------------------|

Total Turnkey Costs

| | |
|---------------------------------|----------------|
| (direct+indirect+contingencies) | <u>459,100</u> |
|---------------------------------|----------------|

Land

| |
|--------------|
| <u>2,000</u> |
|--------------|

Working capital (25% of total direct
operating costs)

| |
|----------------|
| <u>149,800</u> |
|----------------|

GRAND TOTAL

| | |
|--------------------------------|-------------------------|
| (turnkey+land+working capital) | <u><u>\$610,900</u></u> |
|--------------------------------|-------------------------|

^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-12. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING DISTILLATE OIL WITH A THERMAL INPUT OF 8.5 MW
(29×10^6 Btu/h; 700 hp; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|-------------------|
| Direct labor | \$ 105,300 |
| Supervision | <u>68,500</u> |
| Maintenance labor | <u>32,000</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>25,000</u> |
| Electricity | <u>24,000</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>400</u> |
| Fuel | <u>343,000</u> |
| Bottom ash disposal | <u>N.A.</u> |
| Chemicals | <u>1,000</u> |
| Total direct cost | <u>\$ 599,200</u> |

OVERHEAD

| | |
|--------------------------------------|------------------|
| Payroll (30% of direct labor) | <u>\$ 31,600</u> |
| Plant (26% of labor, parts & maint.) | <u>60,000</u> |
| Total overhead costs | <u>\$ 91,600</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | <u>\$ 18,400</u> |
| Capital recovery factor (11.75 % of total turnkey costs) | <u>53,900</u> |
| Interest on working capital (10% of working capital) | <u>15,000</u> |
| Total capital charges | <u>\$ 87,300</u> |

TOTAL ANNUALIZED COSTS

\$ 778,100

a Included with replacement parts.

N.A. - Not applicable.

TABLE B-13. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING NATURAL GAS WITH A THERMAL INPUT OF 1.5 MW
(5 x 10⁶ Btu/h; 125 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

| | |
|----------------------------|--------------------|
| Boiler (with fans & ducts) | \$ 19,100 |
| Stack | 2,000 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | Incl. w/condensate |
| Heaters | N.A. |
| Boiler feed pumps | 3,500 |
| Condensate systems | 4,000 |
| Water treating system | 1,200 |
| Chemical feed | Incl. w/boiler |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 10,000 |
| Total Equipment Cost | \$ 39,800 |

INSTALLATION COST, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 3,000 |
| Stack | 1,000 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | N.A. |
| Heaters | N.A. |
| Boiler feed pumps | 800 |
| Condensate system | 800 |
| Water treating system | 1,000 |
| Chemical feed | 200 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 2,500 |

N.A. - Not applicable.

TABLE B-13. (continued)

| | |
|---|-------------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | <u>2,500</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>12,000</u> |
| Insulation | <u>8,000</u> |
| Painting | <u>2,500</u> |
| Electrical | <u>10,000</u> |
| Buildings | <u>35,000</u> |
| Total installation cost | \$ <u>79,300</u> |
| TOTAL DIRECT COSTS (equipment + installation) | \$ <u>119,100</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ <u>11,900</u> |
| Construction and field expense (10% of direct costs) | <u>11,900</u> |
| Construction fees (10% of direct costs) | <u>11,900</u> |
| Start-up (2% of direct costs) | <u>2,400</u> |
| Performance tests (minimum \$2000) | <u>2,000</u> |
| TOTAL INDIRECT COSTS | \$ <u>40,100</u> |
| Contingencies (20% of direct and indirect costs) | \$ <u>31,800</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>191,000</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>43,600</u> |
| GRAND TOTAL (turnkey+land+working capital) | \$ <u>236,600</u> |

^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-14. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING NATURAL GAS WITH A THERMAL INPUT OF 1.5 MW
(5 x 10⁶ Btu/h; 125 hp; 150 psig/sat. temp. design)

| | |
|--|-------------------|
| DIRECT COST | |
| Direct labor | \$ <u>105,300</u> |
| Supervision | <u>0</u> |
| Maintenance labor | <u>16,000</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>8,000</u> |
| Electricity | <u>6,000</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>100</u> |
| Fuel | <u>38,400</u> |
| Bottom ash disposal | <u>N.A.</u> |
| Chemicals | <u>700</u> |
| Total direct cost | \$ <u>174,500</u> |
| OVERHEAD | |
| Payroll (30% of direct labor) | \$ <u>31,600</u> |
| Plant (26% of labor, parts & maint.) | <u>33,600</u> |
| Total overhead costs | \$ <u>65,200</u> |
| BY-PRODUCT CREDITS | <u>N.A.</u> |
| CAPITAL CHARGES | |
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>7,600</u> |
| Capital recovery factor (11.75% of total turnkey costs) | <u>22,400</u> |
| Interest on working capital (10% of working capital) | <u>4,400</u> |
| Total capital charges | \$ <u>34,400</u> |
| TOTAL ANNUALIZED COSTS | \$ <u>274,100</u> |
| a Included with replacement parts. | |
| N.A. - Not applicable. | |

TABLE B-15. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING NATURAL GAS WITH A THERMAL INPUT OF 4.4 MW
(15 x 10 Btu/h; 300 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|------------------------------|----------------|
| Boiler (with fans and ducts) | \$ 36,100 |
| Stack | 2,700 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerator | 4,000 |
| Heaters | N.A. |
| Boiler feed pumps | 6,100 |
| Condensate systems | 5,000 |
| Water treating system | 1,400 |
| Chemical feed | Incl. w/boiler |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 16,000 |
| Total Equipment Cost | \$ 71,300 |

INSTALLATION COSTS, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 5,000 |
| Stack | 1,500 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerator | 1,500 |
| Heaters | N.A. |
| Boiler feed pumps | 1,200 |
| Condensate system | 1,000 |
| Water treating system | 1,500 |
| Chemical feed | 400 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 3,000 |

N.A. - Not applicable.

TABLE B-15.(continued)

| | |
|--|--------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | 3,500 |
| Duct work (not incl. w/boiler) | N.A. |
| Piping | 20,000 |
| Insulation | 10,000 |
| Painting | 3,000 |
| Electrical | 15,000 |
| Buildings | 50,000 |
| Total Installation Costs | \$ 116,600 |
| TOTAL DIRECT COSTS (Equipment + Installation) | \$ 187,900 |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ 18,800 |
| Construction and field expense (10% of direct costs) | 18,800 |
| Construction fees (10% of direct costs) | 18,800 |
| Startup (2% of direct costs) | 3,800 |
| Performance tests (minimum \$2000) | 2,000 |
| TOTAL INDIRECT COSTS | \$ 62,200 |
| Contingencies (20% of direct and indirect costs) | \$ 50,000 |
| Total turnkey costs (Direct + Indirect + Contingencies) | 300,100 |
| Land | 2,000 |
| Working capital (25% of total direct operating costs) | 87,200 |
| GRAND TOTAL (Turnkey + Land + Working Capital) | \$ 389,300 ✓ |

^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-16. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING NATURAL GAS WITH A THERMAL INPUT OF 4.4 MW
(15 x 10⁶ Btu/h; 300 hp; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|------------|
| Direct labor | \$ 105,300 |
| Supervision | 68,500 |
| Maintenance labor | 32,000 |
| Maintenance materials | a |
| Replacement parts | 15,000 |
| Electricity | 11,600 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 200 |
| Fuel | 115,300 |
| Bottom ash disposal | N.A. |
| Chemicals | 800 |
| Total direct cost | \$ 348,700 |

OVERHEAD

| | |
|--------------------------------------|-----------|
| Payroll (30% of direct labor) | \$ 31,600 |
| Plant (26% of labor, parts & maint.) | 57,400 |
| Total overhead costs | \$ 89,000 |

BYPRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|-----------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 12,000 |
| Capital recovery factor (11.75% of total turnkey costs) | 35,300 |
| Interest on working capital (10% of working capital) | 8,700 |
| Total capital charges | \$ 56,000 |

TOTAL ANNUALIZED COSTS

\$ 493,700

^a Included with replacement parts.

N.A. - Not applicable.

TABLE B-17. ESTIMATED CAPITAL COSTS OF A PACKAGE, FIRE-TUBE BOILER FIRING NATURAL GAS WITH A THERMAL INPUT OF 8.5 MW (29 x 10⁶ Btu/h; 700 hp; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

| | |
|----------------------------|----------------|
| Boiler (with fans & ducts) | \$ 51,000 |
| Stack | 4,000 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 5,000 |
| Heaters | N.A. |
| Boiler feed pumps | 13,000 |
| Condensate systems | 6,000 |
| Water treating system | 2,000 |
| Chemical feed | 1,400 |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 25,000 |

Total Equipment Cost \$ 107,400

INSTALLATION COST, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 9,000 |
| Stack | 2,000 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 2,500 |
| Heaters | N.A. |
| Boiler feed pumps | 3,000 |
| Condensate system | 1,000 |
| Water treating system | 2,000 |
| Chemical feed | 1,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 6,000 |

N.A. - Not applicable.

TABLE B-17. (continued)

| | |
|---|----------------------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | <u>15,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>25,000</u> |
| Insulation | <u>20,000</u> |
| Painting | <u>4,000</u> |
| Electrical | <u>20,000</u> |
| Buildings | <u>70,000</u> |
| Total installation cost | <u>\$ 181,000</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 288,400</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 28,800</u> |
| Construction and field expense (10% of direct costs) | <u>28,800</u> |
| Construction fees (10% of direct costs) | <u>28,800</u> |
| Start-up (2% of direct costs) | <u>5,800</u> |
| Performance tests (minimum \$2000) | <u>2,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 94,200</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 76,500</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>459,100</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>119,800</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u><u>\$ 580,900</u></u> ✓ |

^a Quote from Cleaver-Brooks, May 11, 1978.

N.A. - Not applicable.

TABLE B-18. ESTIMATED ANNUALIZED COSTS OF A PACKAGE, FIRE-TUBE
BOILER FIRING NATURAL GAS WITH A THERMAL INPUT OF 8.5 MW
(29 x 10⁶ Btu/h; 700 hp; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|------------|
| Direct labor | \$ 105,300 |
| Supervision | 68,500 |
| Maintenance labor | 32,000 |
| Maintenance materials | a |
| Replacement parts | 25,000 |
| Electricity | 24,000 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 400 |
| Fuel | 222,900 |
| Bottom ash disposal | N.A. |
| Chemicals | 1,000 |
| Total direct cost | \$ 479,100 |

OVERHEAD

| | |
|--------------------------------------|-----------|
| Payroll (30% of direct labor) | \$ 31,600 |
| Plant (26% of labor, parts & maint.) | 60,000 |
| Total overhead costs | \$ 91,600 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|-----------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 18,400 |
| Capital recovery factor (11.75 % of total turnkey costs) | 53,900 |
| Interest on working capital (10% of working capital) | 12,000 |
| Total capital charges | \$ 84,300 |

TOTAL ANNUALIZED COSTS \$ 655,000

a Included with replacement parts.

N.A. - Not applicable.

APPENDIX C

DETAILED CAPITAL AND ANNUALIZED COST TABLES
FOR DUAL-FUEL BOILERS

TABLE C-1. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|----------------|
| Boiler (with fans & ducts) | \$ 150,000 |
| Stack | 5,000 |
| Instrumentation | incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 7,000 |
| Heaters | N.A. |
| Boiler feed pumps | 13,500 |
| Condensate systems | 3,500 |
| Water treating system | 8,000 |
| Chemical feed | 1,500 |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 33,000 |
| Total Equipment Cost | \$ 221,500 |

INSTALLATION COST, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 10,000 |
| Stack | 3,000 |
| Instrumentation | incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 2,500 |
| Heaters | N.A. |
| Boiler feed pumps | 3,000 |
| Condensate system | 1,000 |
| Water treating system | 2,000 |
| Chemical feed | 1,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 8,000 |

N.A. - Not applicable.

TABLE C-1. (continued)

| INSTALLATION COSTS, DIRECT (cont.) | |
|--|--------------------|
| Foundations and supports | 15,000 |
| Ductwork (not incl. w/boiler) | N.A. |
| Piping | 29,000 |
| Insulation | 20,000 |
| Painting | 4,000 |
| Electrical | 21,000 |
| Buildings | 70,000 |
| Total installation cost | \$ 190,000 |
| TOTAL DIRECT COSTS (equipment + installation) | \$ 411,500 |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | \$ 41,200 |
| Construction and field expense (10% of direct costs) | 41,200 |
| Construction fees (10% of direct costs) | 41,200 |
| Start-up (2% of direct costs) | 8,200 |
| Performance tests (minimum \$2000) | 2,000 |
| TOTAL INDIRECT COSTS | \$ 133,800 |
| Contingencies (20% of direct and indirect costs) | \$ 109,100 |
| Total Turnkey Costs (direct+indirect+contingencies) | 654,400 |
| Land | 2,000 |
| Working capital (25% of total direct operating costs) | 146,500/137,100 |
| GRAND TOTAL (turnkey+land+working capital) | \$ 802,900/793,500 |

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE C-2. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|---------------------|
| Direct labor | \$ 105,300 |
| Supervision | 68,500 |
| Maintenance labor | 32,000 |
| Maintenance materials | a |
| Replacement parts | 30,000 |
| Electricity | 29,300 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 400 |
| Fuel | 319,400/281,900 |
| Bottom ash disposal | N.A. |
| Chemicals | 1,000 |
| Total direct cost | \$ 585,900 /548,400 |

OVERHEAD

| | |
|--------------------------------------|-----------|
| Payroll (30% of direct labor | \$ 31,600 |
| Plant (26% of labor, parts & maint.) | 61,300 |
| Total overhead costs | \$ 92,900 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|-----------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 26,200 |
| Capital recovery factor (10.61% of total turnkey costs) | 69,400 |
| Interest on working capital (10% of working capital) | 14,700/13,700 |
| Total capital charges | 110,300/109,300 |

TOTAL ANNUALIZED COSTS \$ 789,100/750,600

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-3. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

| | |
|----------------------------|----------------|
| Boiler (with fans & ducts) | \$ 280,000 |
| Stack | 9,500 |
| Instrumentation | incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 13,500 |
| Heaters | N.A. |
| Boiler feed pumps | 18,000 |
| Condensate systems | 4,500 |
| Water treating system | 12,500 |
| Chemical feed | 1,500 |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 41,000 |
| Total Equipment Cost | \$ 380,500 |

INSTALLATION COST, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 15,500 |
| Stack | 4,700 |
| Instrumentation | incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 3,000 |
| Heaters | N.A. |
| Boiler feed pumps | 4,800 |
| Condensate system | 1,100 |
| Water treating system | 2,100 |
| Chemical feed | 1,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 15,500 |

N.A. - Not applicable.

TABLE C-3. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|--------|
| Foundations and supports | 21,000 |
| Ductwork (not incl. w/boiler) | N.A. |
| Piping | 43,000 |
| Insulation | 22,500 |
| Painting | 4,100 |
| Electrical | 26,500 |
| Buildings | 76,500 |

| | |
|-------------------------|-------------------|
| Total installation cost | <u>\$ 241,800</u> |
|-------------------------|-------------------|

TOTAL DIRECT COSTS

| | |
|----------------------------|-------------------|
| (equipment + installation) | <u>\$ 622,300</u> |
|----------------------------|-------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|------------------|
| Engineering (10% of direct costs) | <u>\$ 62,200</u> |
| Construction and field expense (10% of direct costs) | <u>62,200</u> |
| Construction fees (10% of direct costs) | <u>62,200</u> |
| Start-up (2% of direct costs) | <u>12,400</u> |
| Performance tests (minimum \$2000) | <u>3,500</u> |

| | |
|----------------------|-------------------|
| TOTAL INDIRECT COSTS | <u>\$ 202,500</u> |
|----------------------|-------------------|

Contingencies

| | |
|------------------------------------|-------------------|
| (20% of direct and indirect costs) | <u>\$ 165,000</u> |
|------------------------------------|-------------------|

Total Turnkey Costs

| | |
|---------------------------------|----------------|
| (direct+indirect+contingencies) | <u>989,800</u> |
|---------------------------------|----------------|

Land

| |
|--------------|
| <u>2,000</u> |
|--------------|

| | |
|--|------------------------|
| Working capital (25% of total direct operating costs) | <u>238,700/219,900</u> |
|--|------------------------|

GRAND TOTAL

| | |
|--------------------------------|------------------------------|
| (turnkey+land+working capital) | <u>\$1,230,500/1,211,700</u> |
|--------------------------------|------------------------------|

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE C-4. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|--------------------|
| Direct labor | \$ 105,300 |
| Supervision | 68,500 |
| Maintenance labor | 64,100 |
| Maintenance materials | a |
| Replacement parts | 42,000 |
| Electricity | 32,900 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 800 |
| Fuel | 638,900/563,700 |
| Bottom ash disposal | N.A. |
| Chemicals | 2,200 |
| Total direct cost | \$ 954,700/879,500 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor | \$ 31,600 |
| Plant (26% of labor, parts & maint.) | 72,800 |
| Total overhead costs | \$ 104,400 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|--------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 39,600 |
| Capital recovery factor (10.61% of total turnkey costs) | 105,000 |
| Interest on working capital (10% of working capital) | 23,900/22,000 |
| Total capital charges | \$ 168,500/166,600 |

TOTAL ANNUALIZED COSTS \$1,227,600/1,150,500

a. Included with replacement parts.

N.A. - Not applicable.

TABLE C-5. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 29.3 MW
(100 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|----------------|
| Boiler (with fans & ducts) | \$ 440,000 |
| Stack | 12,000 |
| Instrumentation | incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 18,000 |
| Heaters | N.A. |
| Boiler feed pumps | 35,000 |
| Condensate systems | 5,500 |
| Water treating system | 16,000 |
| Chemical feed | 1,500 |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 45,000 |
| Total Equipment Cost | \$ 573,000 |

INSTALLATION COST, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 18,000 |
| Stack | 5,500 |
| Instrumentation | incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 3,500 |
| Heaters | N.A. |
| Boiler feed pumps | 6,000 |
| Condensate system | 1,500 |
| Water treating system | 2,500 |
| Chemical feed | 1,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 18,000 |

N.A. - Not applicable.

TABLE C-5. (continued)

| <u>INSTALLATION COSTS, DIRECT (cont.)</u> | |
|--|------------------------------|
| Foundations and supports | <u>25,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>57,000</u> |
| Insulation | <u>25,000</u> |
| Painting | <u>4,500</u> |
| Electrical | <u>33,000</u> |
| Buildings | <u>88,000</u> |
| Total installation cost | <u>\$ 289,000</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 862,000</u> |
| <u>INSTALLATION COSTS, INDIRECT</u> | |
| Engineering (10% of direct costs) | <u>\$ 86,200</u> |
| Construction and field expense (10% of direct costs) | <u>86,200</u> |
| Construction fees (10% of direct costs) | <u>86,200</u> |
| Start-up (2% of direct costs) | <u>17,200</u> |
| Performance tests (minimum \$2000) | <u>3,500</u> |
| TOTAL INDIRECT COSTS | <u>\$ 279,300</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 228,300</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>1,369,600</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>362,400/331,100</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u>\$1,734,000/1,702,700</u> |

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE C-6. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 29.3 MW
(100 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|------------------------|
| Direct labor | \$ 157,900 |
| Supervision | 68,500 |
| Maintenance labor | 64,100 |
| Maintenance materials | a |
| Replacement parts | 50,000 |
| Electricity | 39,300 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 1,400 |
| Fuel | 1,064,800/939,500 |
| Bottom ash disposal | N.A. |
| Chemicals | 3,700 |
| Total direct cost | \$ 1,449,700/1,324,400 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor | \$ 47,400 |
| Plant (26% of labor, parts & maint.) | 88,500 |
| Total overhead costs | \$ 135,900 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|--------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 54,800 |
| Capital recovery factor (10.61 % of total turnkey costs) | 145,300 |
| Interest on working capital (10% of working capital) | 36,200/33,100 |
| Total capital charges | \$ 236,300/233,200 |

TOTAL ANNUALIZED COSTS \$ 1,821,900/1,693,500

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-7. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|----------------|
| Boiler (with fans & ducts) | \$ 600,000 |
| Stack | 14,500 |
| Instrumentation | incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 21,600 |
| Heaters | N.A. |
| Boiler feed pumps | 53,600 |
| Condensate systems | 6,700 |
| Water treating system | 18,000 |
| Chemical feed | 1,500 |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 50,000 |

Total Equipment Cost \$ 765,900

INSTALLATION COST, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 20,000 |
| Stack | 6,500 |
| Instrumentation | incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 4,000 |
| Heaters | N.A. |
| Boiler feed pumps | 7,500 |
| Condensate system | 1,500 |
| Water treating system | 3,000 |
| Chemical feed | 1,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 20,000 |

N.A. - Not applicable.

TABLE C-7. (continued)

| | |
|---|-------------------------------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | <u>30,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>74,000</u> |
| Insulation | <u>30,000</u> |
| Painting | <u>5,000</u> |
| Electrical | <u>40,000</u> |
| Buildings | <u>100,000</u> |
| Total installation cost | <u>\$ 343,000</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 1,108,900</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 110,900</u> |
| Construction and field expense (10% of direct costs) | <u>110,900</u> |
| Construction fees (10% of direct costs) | <u>110,900</u> |
| Start-up (2% of direct costs) | <u>22,200</u> |
| Performance tests (minimum \$2000) | <u>3,500</u> |
| TOTAL INDIRECT COSTS | <u>\$ 358,400</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 293,500</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>1,760,800</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>513,800/466,800</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u><u>\$ 2,276,600/2,229,60</u></u> |

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE C-8. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|-----------------------|
| Direct labor | \$ 210,600 |
| Supervision | 68,500 |
| Maintenance labor | 64,100 |
| Maintenance materials | a |
| Replacement parts | 60,000 |
| Electricity | 47,100 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 2,100 |
| Fuel | 1,597,200/1,409,300 |
| Bottom ash disposal | N.A. |
| Chemicals | 5,500 |
| Total direct cost | \$2,055,100/1,867,200 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor | \$ 63,200 |
| Plant (26% of labor, parts & maint.) | 104,800 |
| Total overhead costs | \$ 168,000 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|--------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 70,400 |
| Capital recovery factor (10.61 % of total turnkey costs) | 186,800 |
| Interest on working capital (10% of working capital) | 51,400/46,700 |
| Total capital charges | \$ 308,600/303,900 |

TOTAL ANNUALIZED COSTS \$2,531,700/2,339,100

a Included with replacement parts.

N.A. - Not applicable.

TABLE C-9. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, FIELD-ERECTED,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|--------------|
| Boiler (with fans & ducts) | \$ 1,704,000 |
| Stack | 262,800 |
| Instrumentation | 182,400 |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 29,000 |
| Heaters | N.A. |
| Boiler feed pumps | 58,000 |
| Condensate systems | 16,300 |
| Water treating system | 20,000 |
| Chemical feed | 500 |
| Compressed air system | 12,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 150,000 |
| Total Equipment Cost | \$ 2,436,500 |

INSTALLATION COST, DIRECT

| | |
|---|------------|
| Boiler (including founda- tions and steel) | \$ 868,000 |
| Stack | 50,000 |
| Instrumentation | 28,000 |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 5,000 |
| Heaters | N.A. |
| Boiler feed pumps | 8,000 |
| Condensate system | 2,000 |
| Water treating system | 3,500 |
| Chemical feed | 1,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 75,000 |

N.A. - Not applicable.

TABLE C-9. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|---------------------|
| Foundations and supports | <u>144,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>100,000</u> |
| Insulation | <u>75,000</u> |
| Painting | <u>8,000</u> |
| Electrical | <u>128,000</u> |
| Buildings | <u>304,000</u> |
| Total installation cost | <u>\$ 1,800,000</u> |

| | |
|--|---------------------|
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 4,236,500</u> |
|--|---------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|-------------------|
| Engineering (10% of direct costs) | <u>\$ 423,700</u> |
| Construction and field expense (10% of direct costs) | <u>423,700</u> |
| Construction fees (10% of direct costs) | <u>423,700</u> |
| Start-up (2% of direct costs) | <u>84,700</u> |
| Performance tests (minimum \$2000) | <u>5,000</u> |

| | |
|----------------------|---------------------|
| TOTAL INDIRECT COSTS | <u>\$ 1,360,800</u> |
|----------------------|---------------------|

| | |
|---|---------------------|
| Contingencies (20% of direct and indirect costs) | <u>\$ 1,119,500</u> |
|---|---------------------|

| | |
|--|------------------|
| Total Turnkey Costs (direct+indirect+contingencies) | <u>6,716,800</u> |
|--|------------------|

| | |
|------|--------------|
| Land | <u>2,000</u> |
|------|--------------|

| | |
|--|------------------------|
| Working capital (25% of total direct operating costs) | <u>693,200/630,500</u> |
|--|------------------------|

| | |
|---|--------------------------------------|
| GRAND TOTAL (turnkey+land+working capital) | <u><u>\$ 7,412,000/7,349,300</u></u> |
|---|--------------------------------------|

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE C-10. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, FIELD-ERECTED,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|------------------------------|
| Direct labor | <u>\$ 263,200</u> |
| Supervision | <u>102,700</u> |
| Maintenance labor | <u>96,100</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>100,000</u> |
| Electricity | <u>70,700</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>2,800</u> |
| Fuel | <u>2,129,600/1,879,000</u> |
| Bottom ash disposal | <u>N.A.</u> |
| Chemicals | <u>7,500</u> |
| Total direct cost | <u>\$2,772,600/2,522,000</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | <u>\$ 79,000</u> |
| Plant (26% of labor, parts & maint.) | <u>146,100</u> |
| Total overhead costs | <u>\$ 225,100</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|------------------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | <u>\$ 268,700</u> |
| Capital recovery factor (10.14% of total turnkey costs) | <u>681,100</u> |
| Interest on working capital (10% of working capital) | <u>69,300/63,100</u> |
| Total capital charges | <u>\$1,019,100/1,012,900</u> |

TOTAL ANNUALIZED COSTS \$4,016,800/3,760,000

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-11. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, FIELD-ERECTED,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|--------------|
| Boiler (with fans & ducts) | \$ 2,736,600 |
| Stack | 500,000 |
| Instrumentation | 302,800 |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 60,000 |
| Heaters | N.A. |
| Boiler feed pumps | 150,000 |
| Condensate systems | 25,000 |
| Water treating system | 60,000 |
| Chemical feed | 4,000 |
| Compressed air system | 25,000 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 290,000 |
| Total Equipment Cost | \$ 4,153,400 |

INSTALLATION COST, DIRECT

| | |
|---|-------------------|
| Boiler (including founda- tions and steel) | \$ 1,736,000 |
| Stack | incl. w/equipment |
| Instrumentation | 88,000 |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 12,000 |
| Heaters | N.A. |
| Boiler feed pumps | 18,000 |
| Condensate system | 10,000 |
| Water treating system | 16,000 |
| Chemical feed | 2,000 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 145,000 |

N.A. - Not applicable.

TABLE C-11. (continued)

| <u>INSTALLATION COSTS, DIRECT (cont.)</u> | |
|--|--------------------------------|
| Foundations and supports | <u>264,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>156,000</u> |
| Insulation | <u>100,000</u> |
| Painting | <u>13,000</u> |
| Electrical | <u>272,000</u> |
| Buildings | <u>520,000</u> |
| Total installation cost | <u>\$ 3,352,000</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 7,505,400</u> |
| <u>INSTALLATION COSTS, INDIRECT</u> | |
| Engineering (10% of direct costs) | <u>\$ 750,500</u> |
| Construction and field expense (10% of direct costs) | <u>750,500</u> |
| Construction fees (10% of direct costs) | <u>750,500</u> |
| Start-up (2% of direct costs) | <u>150,100</u> |
| Performance tests (minimum \$2000) | <u>13,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 2,414,600</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 1,984,000</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>11,904,000</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>1,319,900/1,194,600</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u>\$13,225,900/13,100,600</u> |

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE C-12. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, FIELD-ERECTED,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 117.2 MW
(400 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|-------------------------------|
| Direct labor | \$ 473,800 |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>128,200</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>150,000</u> |
| Electricity | <u>110,000</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>5,600</u> |
| Fuel | <u>4,259,100/3,758,000</u> |
| Bottom ash disposal | <u>N.A.</u> |
| Chemicals | <u>16,000</u> |
| Total direct cost | <u>\$ 5,279,600/4,778,500</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | \$ <u>142,100</u> |
| Plant (26% of labor, parts & maint.) | <u>231,100</u> |
| Total overhead costs | <u>\$ 373,200</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|--|-------------------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>476,200</u> |
| Capital recovery factor (10.14% of total turnkey costs) | <u>1,207,100</u> |
| Interest on working capital (10% of working capital) | <u>132,000/119,500</u> |
| Total capital charges | <u>\$ 1,815,300/1,802,800</u> |

TOTAL ANNUALIZED COSTS \$ 7,468,100/6,954,500

a Included with replacement parts.

N.A. - Not applicable.

TABLE C-13. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, FIELD-ERECTED,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/h; 900 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST

| | |
|----------------------------|--------------|
| Boiler (with fans & ducts) | \$ 4,419,000 |
| Stack | 900,000 |
| Instrumentation | 489,000 |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 85,000 |
| Heaters | N.A. |
| Boiler feed pumps | 195,000 |
| Condensate systems | 35,000 |
| Water treating system | 90,000 |
| Chemical feed | 4,000 |
| Compressed air system | 30,000 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 490,000 |
| Total Equipment Cost | \$ 6,737,000 |

INSTALLATION COST, DIRECT

| | |
|---|-------------------|
| Boiler (including founda- tions and steel) | \$ 2,455,000 |
| Stack | incl. w/equipment |
| Instrumentation | 128,000 |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 19,000 |
| Heaters | N.A. |
| Boiler feed pumps | 25,000 |
| Condensate system | 16,000 |
| Water treating system | 28,000 |
| Chemical feed | 2,000 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 245,000 |

N.A. - Not applicable.

TABLE C-13. (continued)

| INSTALLATION COSTS, DIRECT (cont.) | |
|--|--------------------------------|
| Foundations and supports | <u>484,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>279,000</u> |
| Insulation | <u>165,000</u> |
| Painting | <u>22,000</u> |
| Electrical | <u>520,000</u> |
| Buildings | <u>930,000</u> |
| Total installation cost | <u>\$ 5,318,000</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$12,055,000</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 1,205,500</u> |
| Construction and field expense (10% of direct costs) | <u>205,500</u> |
| Construction fees (10% of direct costs) | <u>1,205,500</u> |
| Start-up (2% of direct costs) | <u>241,100</u> |
| Performance tests (minimum \$2000) | <u>16,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 3,873,600</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 3,185,700</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>19,114,300</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>2,215,100/1,995,900</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u>\$21,331,400/21,112,200</u> |

^aQuote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE C-14. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, FIELD-ERECTED,
WATER-TUBE BOILER FIRING RESIDUAL OIL/NATURAL GAS
WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/h; 900 psig/750°F design)

DIRECT COST

| | |
|-----------------------|------------------------------|
| Direct labor | \$ 605,400 |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>224,300</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>225,000</u> |
| Electricity | <u>180,600</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>9,700</u> |
| Fuel | <u>7,453,400/6,576,600</u> |
| Bottom ash disposal | <u>N.A.</u> |
| Chemicals | <u>25,000</u> |
| Total direct cost | <u>\$8,860,300/7,983,500</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | \$ <u>181,600</u> |
| Plant (26% of labor, parts & maint.) | <u>309,800</u> |
| Total overhead costs | \$ <u>491,400</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|------------------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>764,600</u> |
| Capital recovery factor (10.14 % of total turnkey costs) | <u>1,938,200</u> |
| Interest on working capital (10% of working capital) | <u>221,500/199,600</u> |
| Total capital charges | <u>\$2,924,300/2,902,400</u> |

TOTAL ANNUALIZED COSTS \$12,276,000/11,377,300

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-15. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|----------------|
| Boiler (with fans & ducts) | \$ 150,000 |
| Stack | 5,000 |
| Instrumentation | incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 7,000 |
| Heaters | N.A. |
| Boiler feed pumps | 13,500 |
| Condensate systems | 3,500 |
| Water treating system | 8,000 |
| Chemical feed | 1,500 |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 26,000 |
| Total Equipment Cost | \$ 214,500 |

INSTALLATION COST, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 10,000 |
| Stack | 3,000 |
| Instrumentation | incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 2,500 |
| Heaters | N.A. |
| Boiler feed pumps | 3,000 |
| Condensate system | 1,000 |
| Water treating system | 2,000 |
| Chemical feed | 1,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 6,000 |

N.A. - Not applicable.

TABLE C-15. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|-------------------|
| Foundations and supports | <u>15,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>29,000</u> |
| Insulation | <u>20,000</u> |
| Painting | <u>4,000</u> |
| Electrical | <u>21,000</u> |
| Buildings | <u>70,000</u> |
| Total installation cost | <u>\$ 188,000</u> |

| | |
|--|-------------------|
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 402,500</u> |
|--|-------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|------------------|
| Engineering (10% of direct costs) | <u>\$ 40,300</u> |
| Construction and field expense (10% of direct costs) | <u>40,300</u> |
| Construction fees (10% of direct costs) | <u>40,300</u> |
| Start-up (2% of direct costs) | <u>8,100</u> |
| Performance tests (minimum \$2000) | <u>2,000</u> |

| | |
|----------------------|-------------------|
| TOTAL INDIRECT COSTS | <u>\$ 131,000</u> |
|----------------------|-------------------|

| | |
|---|-------------------|
| Contingencies (20% of direct and indirect costs) | <u>\$ 106,700</u> |
|---|-------------------|

| | |
|--|----------------|
| Total Turnkey Costs (direct+indirect+contingencies) | <u>640,200</u> |
|--|----------------|

| | |
|------|--------------|
| Land | <u>2,000</u> |
|------|--------------|

| | |
|--|------------------------|
| Working capital (25% of total direct operating costs) | <u>175,000/137,100</u> |
|--|------------------------|

| | |
|---|----------------------------------|
| GRAND TOTAL (turnkey+land+working capital) | <u><u>\$ 817,200/779,300</u></u> |
|---|----------------------------------|

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE C-16. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 8.8 MW
(30 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|--------------------|
| Direct labor | \$ 105,300 |
| Supervision | 68,500 |
| Maintenance labor | 32,000 |
| Maintenance materials | a |
| Replacement parts | 30,000 |
| Electricity | 29,300 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 400 |
| Fuel | 433,600/281,900 |
| Bottom ash disposal | N.A. |
| Chemicals | 1,000 |
| Total direct cost | \$ 700,100/548,400 |

OVERHEAD

| | |
|--------------------------------------|-----------|
| Payroll (30% of direct labor | \$ 31,600 |
| Plant (26% of labor, parts & maint.) | 61,300 |
| Total overhead costs | \$ 92,900 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|--------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 25,600 |
| Capital recovery factor (10.61 % of total turnkey costs) | 67,900 |
| Interest on working capital (10% of working capital) | 17,500/13,700 |
| Total capital charges | \$ 111,000/107,200 |

| | |
|------------------------|--------------------|
| TOTAL ANNUALIZED COSTS | \$ 904,000/748,500 |
|------------------------|--------------------|

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-17. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS
DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|----------------|
| Boiler (with fans & ducts) | \$ 280,000 |
| Stack | 9,500 |
| Instrumentation | incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 13,500 |
| Heaters | N.A. |
| Boiler feed pumps | 18,000 |
| Condensate systems | 4,500 |
| Water treating system | 12,500 |
| Chemical feed | 1,500 |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 32,000 |
| Total Equipment Cost | \$ 371,500 |

INSTALLATION COST, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 15,500 |
| Stack | 4,700 |
| Instrumentation | incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 3,000 |
| Heaters | N.A. |
| Boiler feed pumps | 4,800 |
| Condensate system | 1,100 |
| Water treating system | 2,100 |
| Chemical feed | 1,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 11,500 |

N.A. - Not applicable.

TABLE C-17. (continued)

| | |
|---|------------------------------|
| INSTALLATION COSTS, DIRECT (cont.) | |
| Foundations and supports | <u>21,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>43,000</u> |
| Insulation | <u>22,500</u> |
| Painting | <u>4,100</u> |
| Electrical | <u>26,500</u> |
| Buildings | <u>76,500</u> |
| Total installation cost | <u>\$ 237,800</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 609,300</u> |
| INSTALLATION COSTS, INDIRECT | |
| Engineering (10% of direct costs) | <u>\$ 60,900</u> |
| Construction and field expense (10% of direct costs) | <u>60,900</u> |
| Construction fees (10% of direct costs) | <u>60,900</u> |
| Start-up (2% of direct costs) | <u>12,200</u> |
| Performance tests (minimum \$2000) | <u>3,500</u> |
| TOTAL INDIRECT COSTS | <u>\$ 198,400</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 161,500</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>969,200</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>295,800/219,900</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u>\$1,267,000/1,191,100</u> |

^aQuote from Zurn Industries, Inc., May 25, 1979.

N.A. - Not applicable.

TABLE C-18. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 17.6 MW
(60 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|---------------------|
| Direct labor | \$ 105,300 |
| Supervision | 68,500 |
| Maintenance labor | 64,100 |
| Maintenance materials | a |
| Replacement parts | 42,000 |
| Electricity | 32,900 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 800 |
| Fuel | 867,200/563,700 |
| Bottom ash disposal | N.A. |
| Chemicals | 2,200 |
| Total direct cost | \$1,183,000/879,500 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor | \$ 31,600 |
| Plant (26% of labor, parts & maint.) | 72,800 |
| Total overhead costs | \$ 104,400 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|--------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 38,800 |
| Capital recovery factor (10.61 % of total turnkey costs) | 102,800 |
| Interest on working capital (10% of working capital) | 29,600/22,000 |
| Total capital charges | \$ 171,200/163,600 |

TOTAL ANNUALIZED COSTS \$1,458,600/1,147,500

a Included with replacement parts.

N.A. - Not applicable.

TABLE C-19. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 29.3 MW
(100×10^6 Btu/h; 150 psig/sat. temp. design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|----------------|
| Boiler (with fans & ducts) | \$ 440,000 |
| Stack | 12,000 |
| Instrumentation | incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 18,000 |
| Heaters | N.A. |
| Boiler feed pumps | 35,000 |
| Condensate systems | 5,500 |
| Water treating system | 16,000 |
| Chemical feed | 1,500 |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 35,000 |

Total Equipment Cost \$ 563,000

INSTALLATION COST, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 18,000 |
| Stack | 5,500 |
| Instrumentation | incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 3,500 |
| Heaters | N.A. |
| Boiler feed pumps | 6,000 |
| Condensate system | 1,500 |
| Water treating system | 2,500 |
| Chemical feed | 1,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 13,500 |

N.A. - Not applicable.

TABLE C-19. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|---------------|
| Foundations and supports | <u>25,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>57,000</u> |
| Insulation | <u>25,000</u> |
| Painting | <u>4,500</u> |
| Electrical | <u>33,000</u> |
| Buildings | <u>88,000</u> |

| | |
|-------------------------|-------------------|
| Total installation cost | <u>\$ 284,500</u> |
|-------------------------|-------------------|

TOTAL DIRECT COSTS

| | |
|----------------------------|-------------------|
| (equipment + installation) | <u>\$ 847,500</u> |
|----------------------------|-------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|------------------|
| Engineering (10% of direct costs) | <u>\$ 84,800</u> |
| Construction and field expense (10% of direct costs) | <u>84,800</u> |
| Construction fees (10% of direct costs) | <u>84,800</u> |
| Start-up (2% of direct costs) | <u>17,000</u> |
| Performance tests (minimum \$2000) | <u>3,500</u> |

| | |
|----------------------|-------------------|
| TOTAL INDIRECT COSTS | <u>\$ 274,900</u> |
|----------------------|-------------------|

Contingencies

| | |
|------------------------------------|-------------------|
| (20% of direct and indirect costs) | <u>\$ 224,500</u> |
|------------------------------------|-------------------|

Total Turnkey Costs

| | |
|---------------------------------|------------------|
| (direct+indirect+contingencies) | <u>1,346,900</u> |
|---------------------------------|------------------|

Land

| |
|--------------|
| <u>2,000</u> |
|--------------|

Working capital (25% of total direct
operating costs)

| |
|------------------------|
| <u>457,600/331,100</u> |
|------------------------|

GRAND TOTAL

(turnkey+land+working capital)

| |
|-------------------------------------|
| <u><u>\$1,806,500/1,680,000</u></u> |
|-------------------------------------|

^aQuote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE C-20. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 29.3 MW
(100 x 10⁶ Btu/h; 150 psig/sat. temp. design)

DIRECT COST

| | |
|-----------------------|------------------------|
| Direct labor | \$ 157,900 |
| Supervision | 68,500 |
| Maintenance labor | 64,100 |
| Maintenance materials | a |
| Replacement parts | 50,000 |
| Electricity | 39,300 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 1,400 |
| Fuel | 1,445,400/939,500 |
| Bottom ash disposal | N.A. |
| Chemicals | 3,700 |
| Total direct cost | \$ 1,830,300/1,324,400 |

OVERHEAD

| | |
|--------------------------------------|------------|
| Payroll (30% of direct labor | \$ 47,400 |
| Plant (26% of labor, parts & maint.) | 88,500 |
| Total overhead costs | \$ 135,900 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|--------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ 53,900 |
| Capital recovery factor (10.61 % of total turnkey costs) | 142,900 |
| Interest on working capital (10% of working capital) | 45,800/33,100 |
| Total capital charges | \$ 242,600/229,900 |

TOTAL ANNUALIZED COSTS \$ 2,208,800/1,690,200

a Included with replacement parts.

N.A. - Not applicable.

TABLE C-21. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 44 MW
(150 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|----------------|
| Boiler (with fans & ducts) | \$ 600,000 |
| Stack | 14,500 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 21,600 |
| Heaters | N.A. |
| Boiler feed pumps | 53,600 |
| Condensate systems | 6,700 |
| Water treating system | 18,000 |
| Chemical feed | 1,500 |
| Compressed air system | N.A. |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 39,000 |

Total Equipment Cost \$ 754,900

INSTALLATION COST, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 20,000 |
| Stack | 6,500 |
| Instrumentation | Incl. w/boiler |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 4,000 |
| Heaters | N.A. |
| Boiler feed pumps | 7,500 |
| Condensate system | 1,500 |
| Water treating system | 3,000 |
| Chemical feed | 1,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 15,000 |

N.A. - Not applicable.

TABLE C-21. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|----------------|
| Foundations and supports | <u>30,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>74,000</u> |
| Insulation | <u>30,000</u> |
| Painting | <u>5,000</u> |
| Electrical | <u>40,000</u> |
| Buildings | <u>100,000</u> |

| | |
|-------------------------|-------------------|
| Total installation cost | <u>\$ 338,000</u> |
|-------------------------|-------------------|

| | |
|--|--------------------|
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$1,092,900</u> |
|--|--------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|-------------------|
| Engineering (10% of direct costs) | <u>\$ 109,300</u> |
| Construction and field expense (10% of direct costs) | <u>109,300</u> |
| Construction fees (10% of direct costs) | <u>109,300</u> |
| Start-up (2% of direct costs) | <u>21,900</u> |
| Performance tests (minimum \$2000) | <u>3,500</u> |

| | |
|----------------------|-------------------|
| TOTAL INDIRECT COSTS | <u>\$ 353,300</u> |
|----------------------|-------------------|

| | |
|---|-------------------|
| Contingencies (20% of direct and indirect costs) | <u>\$ 289,200</u> |
|---|-------------------|

| | |
|--|------------------|
| Total Turnkey Costs (direct+indirect+contingencies) | <u>1,735,400</u> |
|--|------------------|

| | |
|------|--------------|
| Land | <u>2,000</u> |
|------|--------------|

| | |
|--|-----------------------------|
| Working capital (25% of total direct operating costs) | <u>656,500/ 466,800</u> |
|--|-----------------------------|

| | |
|---|-----------------------------------|
| GRAND TOTAL (turnkey+land+working capital) | <u>\$2,393,900/ 2,204,200</u> |
|---|-----------------------------------|

^aBased on quote from Zurn Industries, Inc., May 25, 1978.

N.A. - Not applicable.

TABLE C-22. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, PACKAGE,
WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS
WITH A THERMAL INPUT OF 44 MW
(150×10^6 Btu/h, 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|------------------------------|
| Direct labor | \$ <u>210,600</u> |
| Supervision | <u>68,500</u> |
| Maintenance labor | <u>64,100</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>60,000</u> |
| Electricity | <u>47,100</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>2,100</u> |
| Fuel | <u>2,168,100/1,409,300</u> |
| Bottom ash disposal | <u>N.A.</u> |
| Chemicals | <u>5,500</u> |
| Total direct cost | <u>\$2,626,000/1,867,200</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor) | \$ <u>63,200</u> |
| Plant (26% of labor, parts & maint.) | <u>104,800</u> |
| Total overhead costs | <u>\$ 168,000</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|---------------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>69,400</u> |
| Capital recovery factor (10.61 % of total turnkey costs) | <u>184,100</u> |
| Interest on working capital (10% of working capital) | <u>65,700/46,700</u> |
| Total capital charges | <u>\$ 319,200/300,200</u> |

TOTAL ANNUALIZED COSTS \$3,113,200/2,335,400

a Included with replacement parts.

N.A. - Not applicable.

TABLE C-23. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, FIELD-ERECTED, WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS WITH A THERMAL INPUT OF 58.6 MW
(200 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

| | |
|----------------------------|--------------|
| Boiler (with fans & ducts) | \$ 1,704,000 |
| Stack | 262,800 |
| Instrumentation | 182,400 |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 29,000 |
| Heaters | N.A. |
| Boiler feed pumps | 58,000 |
| Condensate systems | 16,300 |
| Water treating system | 20,000 |
| Chemical feed | 1,500 |
| Compressed air system | 12,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 100,000 |
| Total Equipment Cost | \$ 2,386,500 |

INSTALLATION COST, DIRECT

| | |
|--|------------|
| Boiler (including foundations and steel) | \$ 868,000 |
| Stack | 50,000 |
| Instrumentation | 28,000 |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 5,000 |
| Heaters | N.A. |
| Boiler feed pumps | 8,000 |
| Condensate system | 2,000 |
| Water treating system | 3,500 |
| Chemical feed | 1,500 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 50,000 |

N.A. - Not applicable.

TABLE C-23. (continued)

| <u>INSTALLATION COSTS, DIRECT (cont.)</u> | |
|--|--------------------------------------|
| Foundations and supports | <u>144,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>100,000</u> |
| Insulation | <u>75,000</u> |
| Painting | <u>8,000</u> |
| Electrical | <u>128,000</u> |
| Buildings | <u>304,000</u> |
| Total installation cost | <u>\$ 1,775,000</u> |
| TOTAL DIRECT COSTS (equipment + installation) | <u>\$ 4,161,500</u> |
| <u>INSTALLATION COSTS, INDIRECT</u> | |
| Engineering (10% of direct costs) | <u>\$ 416,200</u> |
| Construction and field expense (10% of direct costs) | <u>416,200</u> |
| Construction fees (10% of direct costs) | <u>416,200</u> |
| Start-up (2% of direct costs) | <u>83,200</u> |
| Performance tests (minimum \$2000) | <u>5,000</u> |
| TOTAL INDIRECT COSTS | <u>\$ 1,336,800</u> |
| Contingencies (20% of direct and indirect costs) | <u>\$ 1,099,700</u> |
| Total Turnkey Costs (direct+indirect+contingencies) | <u>6,598,000</u> |
| Land | <u>2,000</u> |
| Working capital (25% of total direct operating costs) | <u>883,500/630,500</u> |
| GRAND TOTAL (turnkey+land+working capital) | <u><u>\$ 7,483,500/7,230,500</u></u> |

^a Based on quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE C-24. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, FIELD-ERECTED, WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS WITH A THERMAL INPUT OF 58.6 MW
(200×10^6 Btu/h; 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|------------------------|
| Direct labor | \$ 263,200 |
| Supervision | 102,700 |
| Maintenance labor | 96,100 |
| Maintenance materials | a |
| Replacement parts | 100,000 |
| Electricity | 70,700 |
| Steam | N.A. |
| Cooling water | N.A. |
| Process water | 2,800 |
| Fuel | 2,890,800/1,879,000 |
| Bottom ash disposal | N.A. |
| Chemicals | 7,500 |
| Total direct cost | \$ 3,533,800/2,522,000 |

OVERHEAD

| | |
|--------------------------------------|-----------|
| Payroll (30% of direct labor) | \$79,000 |
| Plant (26% of labor, parts & maint.) | 146,100 |
| Total overhead costs | \$225,100 |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|----------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$263,900 |
| Capital recovery factor (10.14 % of total turnkey costs) | 669,000 |
| Interest on working capital (10% of working capital) | 88,400/63,100 |
| Total capital charges | \$ 1,021,300/996,000 |

TOTAL ANNUALIZED COSTS \$ 4,780,200/3,743,100

a Included with replacement parts.
N.A. - Not applicable.

TABLE C-25. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, FIELD-ERECTED, WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS WITH A THERMAL INPUT OF 117.2 MW (400 x 10⁶ Btu/h; 750 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST^a

| | |
|----------------------------|-------------|
| Boiler (with fans & ducts) | \$2,736,600 |
| Stack | 500,000 |
| Instrumentation | 302,800 |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 60,000 |
| Heaters | N.A. |
| Boiler feed pumps | 150,000 |
| Condensate systems | 25,000 |
| Water treating system | 60,000 |
| Chemical feed | 4,000 |
| Compressed air system | 25,000 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 195,000 |
| Total Equipment Cost | \$4,058,400 |

INSTALLATION COST, DIRECT

| | |
|--|----------------|
| Boiler (including foundations and steel) | \$1,736,000 |
| Stack | Incl. w/equip. |
| Instrumentation | 88,000 |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 12,000 |
| Heaters | N.A. |
| Boiler feed pumps | 18,000 |
| Condensate system | 10,000 |
| Water treating system | 16,000 |
| Chemical feed | 2,000 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 97,000 |

N.A. - Not applicable.

TABLE C-25. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|----------------|
| Foundations and supports | <u>264,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>156,000</u> |
| Insulation | <u>100,000</u> |
| Painting | <u>13,000</u> |
| Electrical | <u>272,000</u> |
| Buildings | <u>520,000</u> |

| | |
|-------------------------|--------------------|
| Total installation cost | <u>\$3,304,000</u> |
|-------------------------|--------------------|

TOTAL DIRECT COSTS

| | |
|----------------------------|--------------------|
| (equipment + installation) | <u>\$7,362,400</u> |
|----------------------------|--------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|-------------------|
| Engineering (10% of direct costs) | <u>\$ 736,200</u> |
| Construction and field expense (10% of direct costs) | <u>736,200</u> |
| Construction fees (10% of direct costs) | <u>736,200</u> |
| Start-up (2% of direct costs) | <u>147,200</u> |
| Performance tests (minimum \$2000) | <u>13,000</u> |

| | |
|----------------------|--------------------|
| TOTAL INDIRECT COSTS | <u>\$2,368,800</u> |
|----------------------|--------------------|

Contingencies

| | |
|------------------------------------|--------------------|
| (20% of direct and indirect costs) | <u>\$1,946,200</u> |
|------------------------------------|--------------------|

Total Turnkey Costs

| | |
|---------------------------------|-------------------|
| (direct+indirect+contingencies) | <u>11,677,400</u> |
|---------------------------------|-------------------|

Land

| |
|--------------|
| <u>2,000</u> |
|--------------|

| | |
|--|----------------------------|
| Working capital (25% of total direct operating costs) | <u>1,700,500/1,194,600</u> |
|--|----------------------------|

GRAND TOTAL

| | |
|--------------------------------|--------------------------------|
| (turnkey+land+working capital) | <u>\$13,379,900/12,874,000</u> |
|--------------------------------|--------------------------------|

^a Based on quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE C-26. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, FIELD-ERECTED, WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL GAS WITH A THERMAL INPUT OF 117.2 MW (400 x 10⁶ Btu/h; 750 psig/750°F design)

DIRECT COST

| | |
|-----------------------|-------------------------------|
| Direct labor | \$ <u>473,800</u> |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>128,200</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>150,000</u> |
| Electricity | <u>110,000</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>5,600</u> |
| Fuel | <u>5,781,600/3,758,800</u> |
| Bottom ash disposal | <u>N.A.</u> |
| Chemicals | <u>16,000</u> |
| Total direct cost | \$ <u>6,802,100/4,778,500</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | \$ <u>142,100</u> |
| Plant (26% of labor, parts & maint.) | <u>231,100</u> |
| Total overhead costs | \$ <u>373,200</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|-------------------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>467,100</u> |
| Capital recovery factor (10.14 % of total turnkey costs) | <u>1,184,100</u> |
| Interest on working capital (10% of working capital) | <u>170,100/119,500</u> |
| Total capital charges | \$ <u>1,821,300/1,770,700</u> |

TOTAL ANNUALIZED COSTS \$ 8,996,600/6,922,400

a Included with replacement parts.

N.A. - Not applicable.

TABLE C-27. ESTIMATED CAPITAL COSTS OF A DUAL-FUEL, FIELD-
ERECTED WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL
GAS WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/h; 900 psig/750°F design)

CAPITAL COSTS

DATE OF ESTIMATE June 30, 1978 (FOR COSTS INDEXING)

EQUIPMENT COST ^a

| | |
|----------------------------|--------------|
| Boiler (with fans & ducts) | \$ 4,419,000 |
| Stack | 900,000 |
| Instrumentation | 489,000 |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 85,000 |
| Heaters | N.A. |
| Boiler feed pumps | 195,000 |
| Condensate systems | 35,000 |
| Water treating system | 90,000 |
| Chemical feed | 4,000 |
| Compressed air system | 30,000 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 325,000 |
| Total Equipment Cost | \$ 6,572,000 |

INSTALLATION COST, DIRECT

| | |
|---|----------------|
| Boiler (including founda- tions and steel) | \$ 2,455,000 |
| Stack | Incl. w/equip. |
| Instrumentation | 128,000 |
| Pulverizers | N.A. |
| Feeders | N.A. |
| Crushers | N.A. |
| Deaerators | 19,000 |
| Heaters | N.A. |
| Boiler feed pumps | 25,000 |
| Condensate system | 16,000 |
| Water treating system | 28,000 |
| Chemical feed | 2,000 |
| Coal handling system | N.A. |
| Ash disposal system | N.A. |
| Thawing equipment | N.A. |
| Fuel-oil system | 165,000 |

N.A. - Not applicable.

TABLE C-27. (continued)

INSTALLATION COSTS, DIRECT (cont.)

| | |
|-------------------------------|----------------|
| Foundations and supports | <u>484,000</u> |
| Ductwork (not incl. w/boiler) | <u>N.A.</u> |
| Piping | <u>279,000</u> |
| Insulation | <u>165,000</u> |
| Painting | <u>22,000</u> |
| Electrical | <u>520,000</u> |
| Buildings | <u>930,000</u> |

| | |
|-------------------------|---------------------|
| Total installation cost | \$ <u>5,238,000</u> |
|-------------------------|---------------------|

| | |
|--|----------------------|
| TOTAL DIRECT COSTS (equipment + installation) | \$ <u>11,810,000</u> |
|--|----------------------|

INSTALLATION COSTS, INDIRECT

| | |
|---|---------------------|
| Engineering (10% of direct costs) | \$ <u>1,181,000</u> |
| Construction and field expense (10% of direct costs) | <u>1,181,000</u> |
| Construction fees (10% of direct costs) | <u>1,181,000</u> |
| Start-up (2% of direct costs) | <u>236,200</u> |
| Performance tests (minimum \$2000) | <u>16,000</u> |

| | |
|----------------------|---------------------|
| TOTAL INDIRECT COSTS | \$ <u>3,795,200</u> |
|----------------------|---------------------|

| | |
|---|---------------------|
| Contingencies (20% of direct and indirect costs) | \$ <u>3,121,000</u> |
|---|---------------------|

| | |
|--|-------------------|
| Total Turnkey Costs (direct+indirect+contingencies) | <u>18,726,200</u> |
|--|-------------------|

| | |
|------|--------------|
| Land | <u>2,000</u> |
|------|--------------|

| | |
|--|----------------------------|
| Working capital (25% of total direct operating costs) | <u>2,881,200/1,995,900</u> |
|--|----------------------------|

| | |
|---|---------------------------------|
| GRAND TOTAL (turnkey+land+working capital) | \$ <u>21,609,400/20,724,100</u> |
|---|---------------------------------|

^a Based on quote from Babcock & Wilcox, Inc., August 17, 1978.

N.A. - Not applicable.

TABLE C-28. ESTIMATED ANNUALIZED COSTS OF A DUAL-FUEL, FIELD-
ERECTED, WATER-TUBE BOILER FIRING DISTILLATE OIL/NATURAL
GAS WITH A THERMAL INPUT OF 205.1 MW
(700 x 10⁶ Btu/h; 900 psig/750°F design)

DIRECT COST

| | |
|-----------------------|--------------------------------|
| Direct labor | \$ <u>605,400</u> |
| Supervision | <u>136,900</u> |
| Maintenance labor | <u>224,300</u> |
| Maintenance materials | <u>a</u> |
| Replacement parts | <u>225,000</u> |
| Electricity | <u>180,600</u> |
| Steam | <u>N.A.</u> |
| Cooling water | <u>N.A.</u> |
| Process water | <u>9,700</u> |
| Fuel | <u>10,117,800/6,576,600</u> |
| Bottom ash disposal | <u>N.A.</u> |
| Chemicals | <u>25,000</u> |
| Total direct cost | \$ <u>11,524,700/7,983,500</u> |

OVERHEAD

| | |
|--------------------------------------|-------------------|
| Payroll (30% of direct labor | \$ <u>181,600</u> |
| Plant (26% of labor, parts & maint.) | <u>309,800</u> |
| Total overhead costs | \$ <u>491,400</u> |

BY-PRODUCT CREDITS

N.A.

CAPITAL CHARGES

| | |
|---|-------------------------------|
| G & A, taxes & insurance (4% of total turnkey costs) | \$ <u>749,000</u> |
| Capital recovery factor (10.14 % of total turnkey costs) | <u>1,898,800</u> |
| Interest on working capital (10% of working capital) | <u>288,100/199,600</u> |
| Total capital charges | \$ <u>2,935,900/2,847,400</u> |

TOTAL ANNUALIZED COSTS \$14,952,000/11,322,300

a Included with replacement parts.

N.A. - Not applicable.